POWER PLANT ENGINEERING

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Kansas City Plant Model of Refrigeration Methods

KANSAS CITY COLD STORAGE AND WAREHOUSE CO. HAS NEW PLANT WHICH SHOWS LATEST PRACTICE IN ICE-MAKING AND REFRIGERATION WORK

HAVING STORAGE capacity for 26,000,000 lb. of perishable food stuffs, a refrigeration capacity of 1025 T., an ice storage capacity of 12,000 T., and an ice manufacturing capacity of 100,000 T. a year, the new plant of the Kansas City Cold Storage and Warehouse Co., formally placed in service on Nov. 23, 1922, is a splendid example of the work of modern refrigerating engineering. In all of the details connected with the transfer of electrical energy into the final product, namely low temperatures and ice, it is evident that careful attention has been given to all of the engineering considerations involved in the design of this plant.

Refrigeration is obtained through the use of three refrigerating machines, two of 385-T. nominal daily capacity each and one of 225-T. nominal daily capacity, each unit consisting of two horizontal double-acting twin ammonia compressors arranged for direct connection to synchronous motors as shown in Fig. 1. One particular feature of these machines is that they are provided with double suctions so arranged with bypass valves that either one or both ends of any cylinder can be used for handling high or low temperature gas.

In the 385-T. machines the double acting 17 in. by 36 in. stroke cylinders give a displacement of 9.26 cu. ft. each or 18.52 cu. ft. for the twin compressor. According to the guarantees these units will give the rated refrigerating capacity at 83¾ r.p.m. when the suction gas pressure is not less than 17 lb. and the discharge gas pressure is not less than 177 lb. gage. At this rating the power requirement is 1¼ hp. delivered to the compressor shaft for each ton of refrigeration.

On the same basis the 225-T. unit has a total displacement of 9.04 cu. ft. per revolution and delivers its

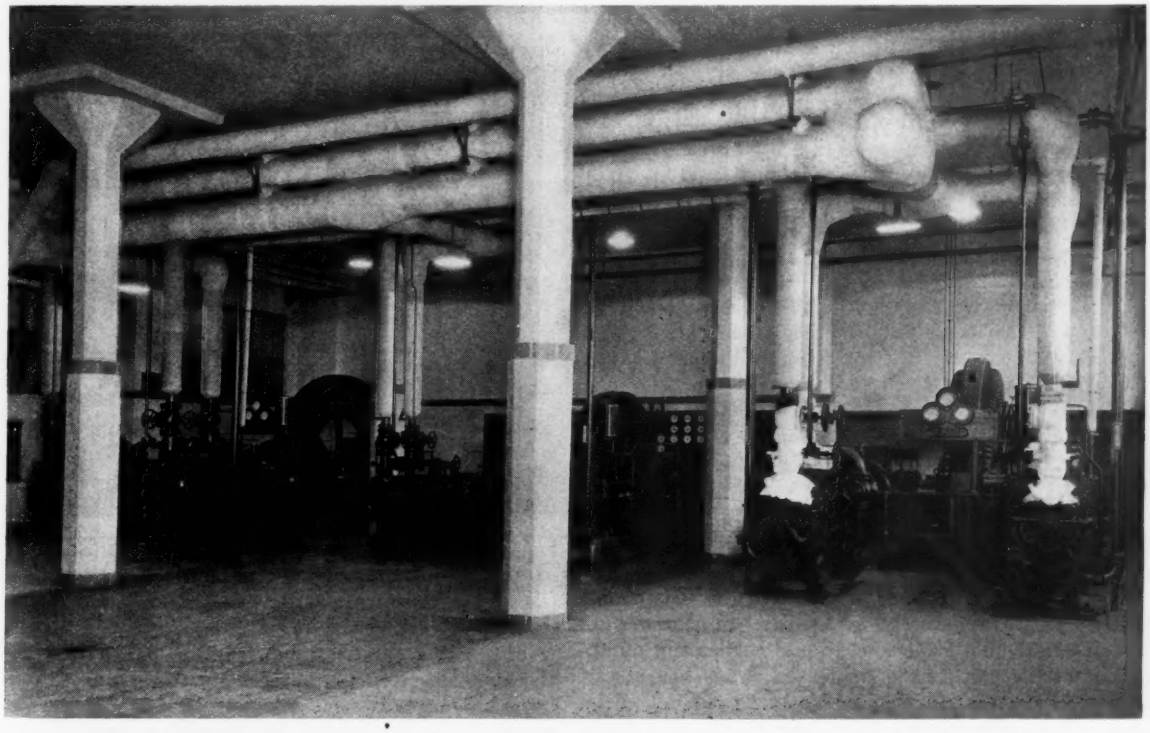


FIG. 1. THERE ARE TWO 385-T. AND ONE 225-T. COMPRESSORS ALL OF WHICH ARE DRIVEN BY SYNCHRONOUS MOTORS

rated capacity at 100 r.p.m. with the same suction and discharge pressure as the larger machines and the driving power required is also 1¼ hp. per ton of refrigeration. Cylinders are water cooled and the suction and discharge valves are located in the compressor heads. Valves are constructed of hammered steel set in steel

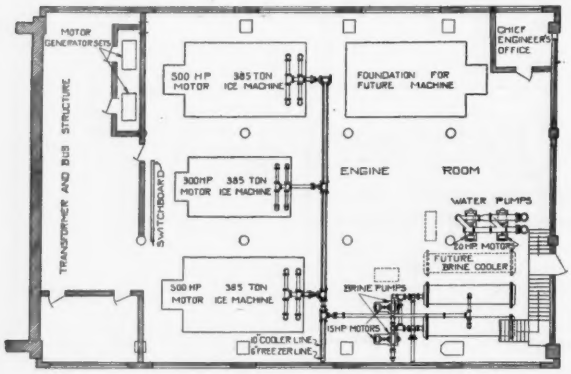


FIG. 2. MACHINE ROOM IS OF AMPLE SIZE TO CARE FOR FUTURE REQUIREMENTS

valve cages held in position by bonnets which can be readily removed. The oiling system is of the Richardson-Phoenix individual type.

Additional apparatus which makes up the refrigerating equipment comprises two 100-T. brine coolers, two 1000-gal. per min. centrifugal water pumps, two 600-gal. per min. centrifugal brine pumps, a 60 stand ammonia condenser, two purge drums, two ammonia liquid receivers, oil separators, a cooling tower and a water softening system. All of the refrigerating equipment was furnished by the Ball Ice Machine Co.

From Figs. 2 and 3 it will be noted how this equipment is arranged with relation to the ice tanks and cooling rooms. The ammonia condenser stands are located at the second floor level of that section of the plant which is above the machine room and the water softener and cooling tower are located on the tank room roof. Purge drums are just above the ammonia condenser and the ammonia receivers are on the floor above the compressors.

There are a number of features of interest in the design of the ammonia condenser. It is made up of 60 independent stands constructed of 2-in. full card weight special ammonia pipe. Each stand is 21 pipes high set 20 in. center to center and so arranged that the stands may be operated separately or together. Stop valves are provided in the hot gas header, liquid header and pumping out header so that the condenser stands for each of the three refrigeration machines may be cut out if desired. This arrangement gives two batteries of three sections each. It is also possible to evacuate any stand of ammonia without interfering with the other stands.

Purge tanks are 12 in. diameter by 9 ft. long and one of them contains an expansion coil. The ammonia liquid receivers are of wrought iron 18 ft. long by 20 in. diameter and are equipped with gage glasses.

Water Supply Is Drawn from City Mains

At the time the site for the plant was chosen no difficulty was anticipated in securing an adequate supply of water for making raw water ice as well as for use with the ammonia condenser. Plans called for sinking wells near the property but when test holes showed that the water tested 85 grains hardness which included 4 grains of iron carbonate this plan had to be abandoned as such water would have been entirely unsuited for the manufacture of clear ice.

One peculiar feature of the water situation was that test holes sunk on the opposite, or north side, of the river gave a water of 25 grains hardness, no sulphates and only ½ grain of iron carbonate. While it would have been possible to pipe the water supply either under the river or over the railroad bridge this would have involved a considerable capital investment. It was therefore decided to use water from the city mains and

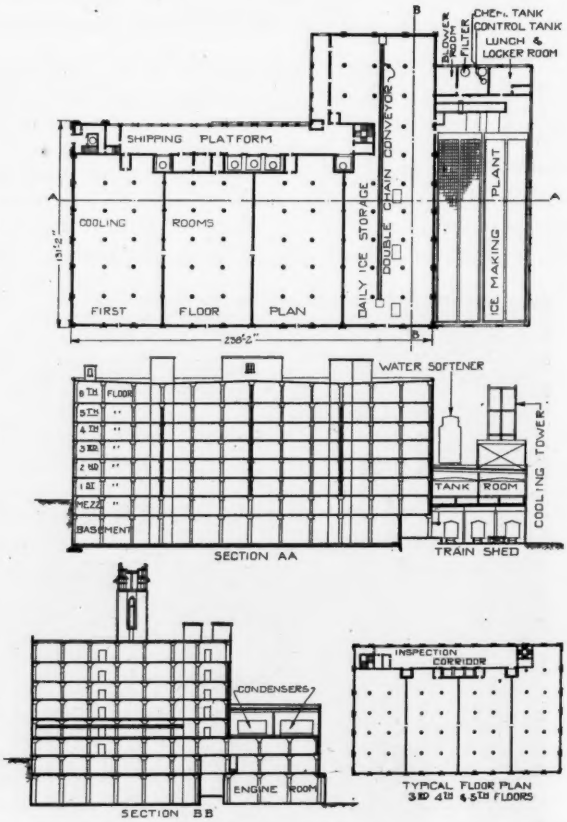


FIG. 3. LAYOUT OF THE BUILDING WAS CHOSEN AFTER CAREFUL ENGINEERING CONSIDERATION OF THE EQUIPMENT WHICH WAS TO BE USED

treat it with a water softening system. This water showed the analysis given in the accompanying table.

While there is some seasonal variation in the water analysis it was decided, for normal operation, to use 2½ lb. of 98 per cent hydrated lime for the water treatment. For this purpose a Graver water softening system with a capacity of 5000 gal. per hr. and a storage capacity of 5000 gal. was installed. As shown in Figs. 3 and 4 the sedimentation tank and the dry chemical storage tanks are set up on the roof of the tank room while the mixing tanks, filter and control tank are located in a room at the end of the tank room.

Hydrated lime is delivered in carload lots and hoisted up to this storage house. Each day's charge is weighed out according to the treatment required and emptied

through a chute into the chemical tank located on the floor below. Here the proper mixture with water takes place. A control tank which regulates the action of a motor driven pump, regulates the amount of the mixture fed to the sedimentation tank in accordance with the demand for treated water. When the chemical mixture is pumped from the control tank it is passed up to the top of the tank shown in Fig. 4 where it enters a weir box where it is mixed with city water and passes to the settling chamber.

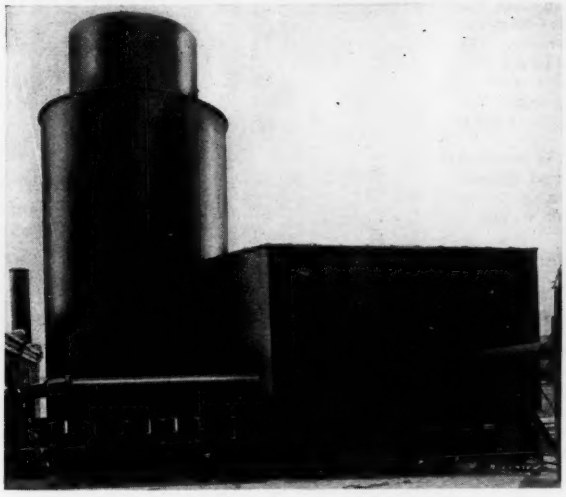
This sedimentation tank is 15 ft. in diameter and 23 ft. 5 in. high with a downtake on the interior, 3 ft. 8 in. in diameter. While the water is passing through this downtake it is agitated by means of paddles operated by a vertical electric motor mounted at the top of the tank.

At the time plans were being considered for the construction of this tank the question arose as to whether it should be constructed of wood or steel. It was thought that a wood tank would not absorb as much heat as a steel tank and therefore the temperature rise during the 5 hr. sedimentation period would not be as great. As every degree increase in temperature at which the water is delivered to the ice cans requires just so much more refrigerating effect for the production of ice, this point was carefully considered. It was finally decided that the maintenance of a steel tank as well as the first cost would be less and therefore would offset the loss due to the slightly higher temperature of the water. During last August it was found that the water delivered to the cans was only 3 deg. F. higher than the city water temperature.

In order to provide for peak loads a storage space of 5000 gal. was provided for in the upper part of the tank which may be drawn on if the rate should temporarily exceed 5000 gal. per hr.

Treated water is drawn off from the side of the tank, a short distance below the water line, and passes from there to the pressure filter in the control room. This filter is 7 ft. in diameter by 7 ft. 7 in. high and the depth of the filtering medium is 28 in. Operation is at a pressure of 20 lb. and the filter supplies 2.2 gal. per min. for each square foot of filter surface. No coagulant such as alum is used as the filter is large enough to take care of the extremely fine suspended matter. Should it be desired, however, to increase the capacity of the filter a layer of coagulant on top of the filter medium could be used.

In order to permit ease of operation the sludge blowoff valve of the sedimentation tank is located in the control room. The pressure filter is cleaned by a backwash valve also located in this room.



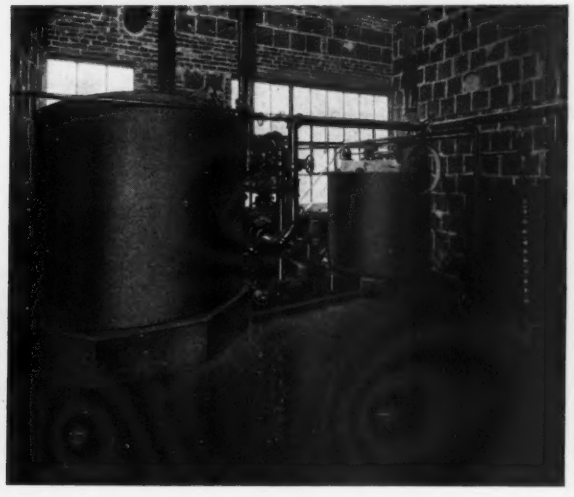


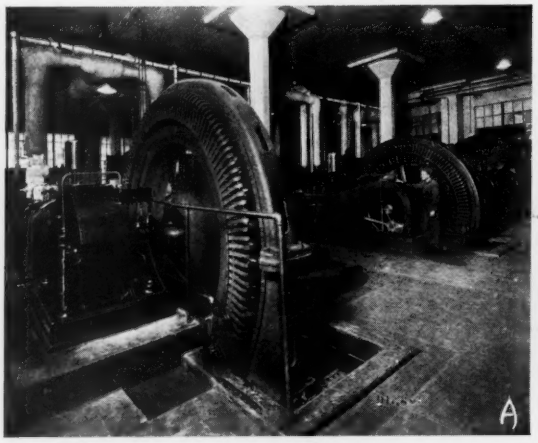
FIG. 4. METHOD OF HANDLING THE WATER SUPPLY IS AN IMPORTANT FEATURE OF THE PLANT

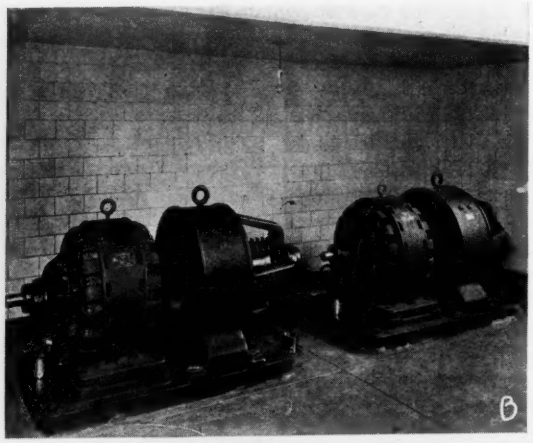
Left.—Sedimentation tank of water softening system has a capacity of 5000 gal. per min. and a storage capacity of 5000 gal. After the lime is added the treated water is allowed to settle for 5 hr. Right.—Equipment in the water treatment control room consists of a chemical mixer, control tank and a pressure filter. Upper.—After treatment the water flows to the can filling tanks shown just below and at the rear of the can hoist crane.

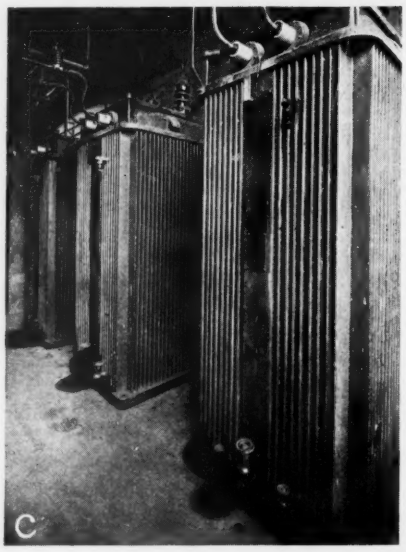
Cooling Tower Used for Ammonia Condenser Water

Water for the ammonia condenser is cooled by means of a cooling tower furnished by the Water Cooling Equipment Co. of 2000 gal. per min. capacity located on

Fig. 5—High Power Factor Is Maintained Through Use of Synchronous Motor Drive







A. 500 hp. synchronous motors are used for driving the 385-T. compressors and a 300 hp. synchronous motor for the 225-T. machine.

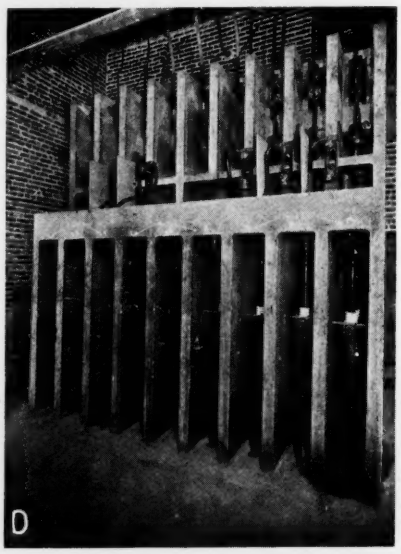
B. Synchronous motors are also used in the motor generator sets which supply the excitation.

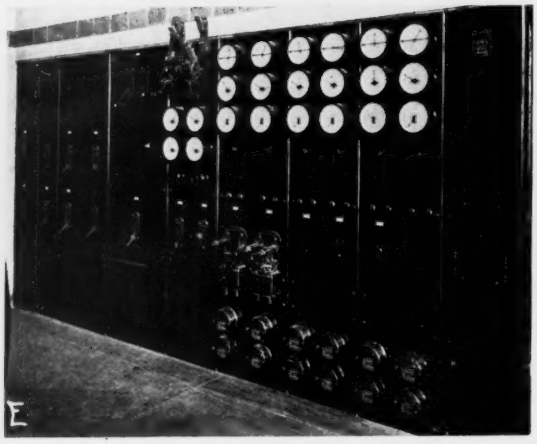
C. Energy is supplied at 132,000 v. and stepped down with these transformers to 2300 v., 220 v. and 110 v.

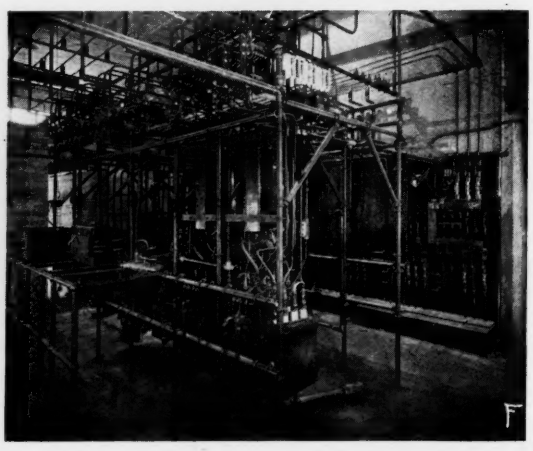
D. Oil switch compartments where the 13,200 v. and the 2300 v. oil switches are located.

E. The switchboard has full remote control equipment.

F. On this bus structure are mounted the starting and running switches for operating the synchronous motors.







the roof of the building just over the condensers. Make up water due to evaporation and windage losses which amount to about 10 per cent, is taken from the city.

While it would have been possible to have drawn the supply of cooling water from wells sunk near the plant it was considered more economical to use a cooling tower. The temperature of the ground water is from 57 to 60 deg. F. the year round and with a cooling tower it is possible to obtain much lower temperatures during at least 8 mo. of the year. One plan, however, which may yet be used is to draw the make-up water from the river, filter it, and then pass it over the cooling tower. It is estimated that this would save about $5000 a year in water make-up charge which must now be paid to the city.

During the consideration of cooling water equipment a spray pond to be located on the roof of the building was considered. Due, however, to the fact that the building design was so far along at the time this was considered, it would not have been practicable to use such a system even though other economic considerations might have warranted a further study.

ANALYSIS OF WATER USED IN KANSAS CITY PLANT

	Grains per gal.
Calcium carbonate	14.82
Magnesium carbonate	0.28
Magnesium sulphate	8.23
Iron and aluminum oxides	0.18
Iron and aluminum sulphates	1.24
Total encrustants	24.75
Sodium sulphate	10.51
Sodium chloride	3.27
Total non-encrustants	13.78
Total solids	38.53
Total hardness	27.07
Alkalinity	15.15

As ice making is an important feature of the operation considerable thought was given to the design of this section of the plant in order to handle the work efficiently. The tank room, as will be noted from Fig. 3, is located above the train shed. There are two tanks, 29 ft. 8 in. by 122 ft. 2 in., each of which has a capacity of 1344—400-lb. cans. Each tank has a center partition and suitable bulkheads for proper brine circulation. Over 85,000 ft. of 1¼-in. special extra heavy ammonia pipe was used for expansion piping.

Air agitation is supplied by two positive pressure Connersville blowers and as a low pressure system is used the agitation takes place at 2½ to 3 lb. pressure. Cores are pumped with a motor driven core pump.

There are two crane ice can hoists which were supplied by the Euclid Crane & Hoist Co. Six cans are handled at a time and the dip and pump tanks are likewise equipped to handled the 6-can units. There are two can fillers, one for each tank, which are located at the dump end of the tanks.

After the ice has reached the dump it is taken to the daily storage space by a chain conveyor. This conveyor runs at right angles to the storage room and so the ice is automatically transferred to another chain conveyor which runs the full length of the storage space. In addition to these conveyors there are also three ice hoists which serve to place ice into either one of two permanent storages, to the car icing platform in the train shed, or to load cars. These hoists can also be used to take ice from the permanent storages if there should be an unusual demand for ice to be taken by trucks. A Creasey ice crusher is also in use. All of this handling equipment was supplied by the Gifford-Wood Co.

From the sectional views of the building shown in Fig. 3 it will be seen that there are six floors above the grade level and a mezzanine floor and basement below the grade. At the basement level is the machine room, reserve ice storage and the train shed. The space of the mezzanine floor is also used for reserve ice storage and for the machine shop and store room which are located directly over the engine room. On the first floor are located the ice making plant, and daily ice storage which have been previously mentioned. There are also three storage rooms located on this floor and a shipping platform where trucks may be loaded.

Above the first floor are five other floors which are devoted to space for cooling rooms. The first and second floors are equipped with 2-in. direct expansion piping for carrying temperatures to 10 deg. F. below zero. At the third floor the equipment consists of both direct expansion and brine coils. The brine coils are used when it is desired to maintain the rooms and coolers with a temperature of 32 deg. F. and the expansion coils are used if freezing temperatures are desired. Equipment of the three floors above the third consists of brine coils for maintaining cooling temperatures. The third and fourth floors are also equipped with the Moore system of ventilation whereby it is possible to maintain proper circulation of air and also to control the humidity.

One unusual electrical feature in the storage rooms is the use of plug outlets which are connected to a power circuit. These outlets are used for plugging in portable electric hoists which are used for stocking crates and other such work. There are four or five of these power outlets located on the columns, at strategic points on each floor. The switches which control the lighting circuits are placed in the inspection corridors and are provided with red pilot lamp bull's-eyes which indicate whether the lights are on.

There are six freight elevators of 5000 lb. capacity each and one passenger elevator which serve the storage floors. These machines are of the tandem worm-gear traction type, electrically driven, and were furnished by the Pitt Engineering Co.

Electrical Features of the Machine Room

Electrical energy for the operation of the plant is supplied by the Kansas City Light & Power Co. Current is fed into the machine room at 13,200 v. and stepped down with a bank of transformers to 2300 v. for the compressor motors and to 220 v. for the elevator and other motors and to 110 v. for the lighting circuits.

In Fig. 5 a number of views of the electrical layout are shown. The current comes in through the high tension oil switches shown in Fig. 5D, passes to the transformers shown in Fig. 5C and then back at 2300 v. to the oil switches shown in the right hand compartments of the switch structure shown in Fig. 5C. The 220-v.

breakers are in the three left hand compartments shown in the same view.

Motor drive for the compressors is taken care of by 2300-v. synchronous motors. The two motors driving the 385-T. machines are rated at 500 hp. each. These motors are of the engine type, 3-phase, 60-cycle, 100 per cent power factor, 90 pole and operate at a speed of 80 r.p.m. As shown in Fig. 5A they are direct-connected, without flywheels. The rotors are of split construction and auto-transformers are used for starting. The motor for the 225-T. ice machine is of the same type, with a rating of 300 hp. at 100 r.p.m. All of these motors are guaranteed to carry their rated load with a 90 per cent leading power factor with a maximum temperature rise of 50 deg. C.

In order to obtain the direct current for excitation two 75-kw. generators, direct connected to 112-hp. synchronous motors, are used. One of these sets is shown in Fig. 5B.

Starting of the synchronous motors is accomplished from the switch board shown in Fig. 5E. Each motor is equipped with an oil switch for starting and one for running. These switches are mounted on the bus structure frame work just back of the switch board as will be noted from Fig. 5F. Each compressor motor panel is equipped with a reactive factor meter, field, ammeter, line ammeter, over load relays and stop push buttons.

In order to segregate the power costs each large motor has a meter and in addition the small motors are classified as to work performed and placed on a metered circuit. In this way it is possible to arrive at the power consumption for any particular part of the work.

Electrical equipment in the machine room was supplied by the Westinghouse Electric & Mfg. Co. and installed by the O. M. George Co.

Heating requirements of the plant are taken care of by a boiler room just off the machine room. Equipment in this boiler room consists of two 30-hp. Kewanee portable type fire box boilers. Oil is used for fuel and the furnaces are fitted with Ray burners. As the system is laid out for automatic operation practically no attention is required.

Comprehensive Record System Is Used

In connection with the operation of the refrigerating and ice making equipment a record system has been devised which furnishes complete information on the cost per ton of refrigeration produced. The feature of this record system is in the machine room log sheet which is used. From the reproduction of this log sheet shown in Fig. 6, it can be seen that all operations are recorded which affect the cost.

Readings are taken every 2 hr. of the suction pressures and temperatures, ammeter and power factor meters; temperatures of ice tanks, ice storage, water to and from condensers, ammonia liquor, ice tank suction and the brine system. In addition there is a report made of the elevator and sprinkler system inspection. Daily readings are also taken of the electric meters, water meters and the fuel oil meters on the heating plant.

From the pressure and temperature readings the refrigeration in tons is calculated and as it is possible to figure the kilowatt hours to produce this amount of refrigeration, the power cost per ton of refrigeration is readily calculated.

DAILY PLANT LOG— Kansas City Cold Storage & Warehouse Co. DATE 11/28/22

COMPRESSOR PRESSURES & TEMPERATURES METER READING — REFRIGERATING MACHINES — MEAN PRESS HOURS RUN

	TIME	8 A.M.	10 A.M.	12 M.	2 P.M.	4 P.M.	6 P.M.	8 P.M.	10 P.M.	12 M.	2 A.M.	4 A.M.	6 A.M.	
NO. 1 MACH 17" X 36" 1482 CU. FT. PER MIN.	PRESS. HIGH													
	PRESS. L.T. LOW													
	PRESS. H.T. LOW													
	TEMPS. L.T. SUCT.													
	TEMPS. H.T. SUCT.													
	TEMPS. DISCH.													
	AMMETER													HOURS
	P. F. METER													
NO. 2 MACH. 12" X 36" 904 CU. FT. PER MIN.	PRESS. HIGH		100	105	110	110			105	100	100	100	95	102.78
	PRESS. L.T. LOW		2	4	5	2			3	2	2	3	4	3.00
	PRESS. H.T. LOW		17	20	24	5			15	20	20	20	15	18.44
	TEMPS. L.T. SUCT.		-22	-19	-17	-10			-5	-7	-23	-20	-20	
	TEMPS. H.T. SUCT.		13	19	20	5			15	23	20	21	10	
	TEMPS. DISCH.		85	80	100	100			100	95	90	90	90	
	AMMETER		51	52	57	32			52	54	53	53	44	HOURS
	P. F. METER		98	98	98	98			97	98	98	98	98	18.06
NO. 3 MACH. 17" X 36" 1482 CU. FT. PER MIN.	PRESS. HIGH	105						105						105.0
	PRESS. L.T. LOW	1						4						2.50
	PRESS. H.T. LOW	10						10						10.00
	TEMPS. L.T. SUCT.	-26						-5						
	TEMPS. H.T. SUCT.	-14						20						
	TEMPS. DISCH.	185						200						
	AMMETER	62						60						HOURS
	P. F. METER	100						100						3.42
NO. 4 MACH	PRESS. HIGH													
	PRESS. L.T. LOW													
	PRESS. H.T. LOW													
	TEMPS. L.T. SUCT.													
	TEMPS. H.T. SUCT.													
	TEMPS. DISCH.													
	AMMETER													HOURS
	P. F. METER													
TEMPERATURES	ICE TANK No. 1	17	17	17	17	17	18	18	18	17	17	17	17	
	ICE TANK No. 2	17	18	18	19	21	25	24	21	18	18	19	20	
	DAILY ICE STGE.	23	23	23	24	24	24	24	25	26	26	26	26	
	CITY WATER	47	47	47	47	46	47	47	47	48	48	48	48	47.25
	WATER TO COND.	48	46	47	49	48	—	48	48	46	46	46	45	46.82
	WATER FR. COND.	53	50	51	54	53	—	52	52	50	50	50	50	51.27
	AMMONIA LIQUOR	51	50	53	57	47	—	50	50	52	51	52	50	
	No. 1 ICE T. SUCT.	18	18	18	18	18	25	20	20	17	16	16	17	
	No. 2 ICE T. SUCT.	18	19	19	19	22	27	26	21	18	17	18	21	
	OUT DOOR -	40	41	44	46	46	46	45	45	40	40	39	42.67	

ELEVATORS

ELEV.	MOTORS INSPECTED	CONTROL B'RD INSPECTED	CABLES INSPECTED	GUIDES GREASED	REPAIRS AND REMARKS
NO. 1	9th A.M	9th A.M	9th A.M		Construction men working on No. 1-2-4-6 elevators and gates.
" 2	" "	" "	" "	" "	
" 3	" "	" "	" "	" "	
" 4					
" 5	" "	" "	" "	" "	Adjusted top safety cutout on No. 5
" 6					

	8 A.M. DAILY	A. C. SERVICE	WH'SE LIGHTS	NO. 1 COMP	NO. 2 COMP.	NO. 3 COMP.	NO. 4 COMP.	STEAM	
THIS READING	Rev. 3628	51476	03600	113040	204120		5775-4287	METER READINGS TO BE TAKEN AT 9 A.M. EACH DAY
LAST "	1062144	50552	03600	110600	203760		5106-3848	
TOTAL "		924	—	2440	360		228	
		ICE PROD'N	ICE DEL'Y	ELEVATORS	BRINE PUMPS	WATER PUMPS	WATER	
THIS READING		73230	00352	08160	39072		1250390	
LAST "		72110	00348	08000	38536		1238140	
TOTAL "		1120	4	160	536		12250	

SPRINKLER SYSTEM

INSPECTED	BANK NO. 1 BASEM'T & MEZZ.			BANK NO. 2 1st & 2nd FLOOR		BANK NO. 3 3rd & 4th FLOOR			BANK NO. 4 5th & 6th FLOOR		
	WATCH 1	WATCH 2	WATCH 3	WATCH 1	WATCH 2	WATCH 3	WATCH 1	WATCH 2	WATCH 3	WATCH 1	WATCH 2	WATCH 3
WATER PRESSURE	126	134	142	112	122	127	98	107	115	90	95	105
AIR "	49	46	43	49	46	43	49	45	44	48	45	45
DRY VALVES	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

AMMONIA

RECEIVED	136	CYLINDERS	23556	LBS.
USED	137	"	20687	"
ON HAND	19	"	2818	"

WATER SOFTENER

LIME USED	1st P.M. 39 lb.
SODA ASH USED	—
SLUDGE BLOWN OUT	1st P.M 10th P.M 5th A.M.
FILTER FLUSHED	12th 9th A.M 4th A.M.
HARDNESS TESTED	

ICE MAKING PLANT

	1st WATCH	2nd WATCH	3rd WATCH
400 LB. CANS PULLED No. 1 TANK	—	—	—
400 LB CANS PULLED No. 2 TANK	222	—	180
CAKES PUT INTO DAILY ICE STORAGE	222	—	180

TOTAL ICE PULLED 402 CAKES TONS 80.4

WATER PUMPS	STARTED	STOPPED	TOTAL HRS. RUN
NUMBER 1 ✓	7:30 P.M	4:30 PM	21.50
" 2			
" 3			

BRINE PUMPS	STARTED	STOPPED	TOTAL HRS. RUN
NUMBER 1			
" 2 ✓			24.00
" 3 ✓	1:00 PM 7:30 PM	7:00 PM	2.33

BRINE SYSTEM TEMPERATURES

HOUR	8 A.M.	10 A.M.	12 M.	2 P.M.	4 P.M.	6 P.M.	8 P.M.	10 P.M.	12 M.	2 A.M.	4 A.M.	6 A.M.
SUPPLY	13	15	15	15	0	16	14	12	14	13	14	12
RETURN	23	23	23	22	8	28	22	20	22	28	22	25

ALL TEMPERATURE AND PRESSURE READINGS TO BE TAKEN PROMPTLY AT HOURS DESIGNATED.

CARBON COPY OF THIS TO BE MAILED TO CHICAGO EACH DAY.

USE THE REVERSE SIDE OF THIS SHEET FOR ANY REMARKS THAT ARE TO BE MADE.

ENGINEERS SIGN BELOW—

Form 3

FIG. 6. MACHINE ROOM LOG SHEET WHICH GIVES FULL INFORMATION ON OPERATION OF THE REFRIGERATING AND ICE MAKING EQUIPMENT

In working up the monthly costs the following headings are used in the accounting system: Superintendence, labor, oil, electric power, water, supplies, maintenance of machines and equipment, maintenance of building, liability insurance, waste steam heat, chemicals, water service incidentals, packing, building insurance and depreciation. Totals for each of these headings are entered on a tabulation which is maintained by months so that it is possible to check increases or decreases in the various items of plant expense.

In addition to refrigeration expense a record is also kept of operations in the tank room. The form used shows the two tanks with the can rows numbered. Each rectangle represents six cans and there are four of these units across each tank. In other words, there are 24 cans in each row and 56 rows.

In making a record of the pulls the tank man draws a line through the row pulled and notes the starting time. At the end of shift the number of cans pulled is entered in the tabulation at the bottom of the form. On this same form there is a perpetual inventory maintained of the amount of white and clear ice pulled, sold and the balance on hand. Operating costs are also entered.

In the preparation of this account we are indebted to E. M. Dodds, general manager of the Kansas City Cold Storage & Warehouse Co., and to F. H. Roos, chief engineer, for information on the design and operation of the plant. Mr. Roos is also chief engineer of the United States Cold Storage Co. of Chicago, which is operated in conjunction with the Kansas City plant. W. C. Curd, consulting engineer, supplied information on the water supply system.

Tempering Coal Reduces Draft Requirements

INVESTIGATIONS WITH WESTERN COAL PROVE THAT PROPER TEMPERING IS A DISTINCT AID TO COMBUSTION. BY THOMAS A. MARSH*

FOR YEARS there has been much discussion as to whether or not the addition of moisture to coal was beneficial or detrimental, and if beneficial, for what reason. In general, the theorists were of the opinion that the addition of water was a detriment, while the practical engineers and firemen knew that higher boiler ratings and cleaner ash could be obtained when using moist coal.

As the science of practical coal burning has developed, better results have been noted from properly moistened coal; in fact, some coals are practically nonusable in a dry condition.

Therefore the knowledge of properly wetting coal has developed in a practical manner and the term "tempering" has been applied to the subject.

Many theories have been advanced regarding the merits or otherwise of the practice of tempering coal, such as:

a. Added moisture is a detriment and simply requires that much more heat to vaporize and superheat the additional water.

b. Added moisture penetrates the coal which, when heated, cracks open due to the expansive power of the steam formation, thereby exposing clean, fresh bituminous surfaces which ignite rapidly.

c. Additional moisture is beneficial because it causes a more compact fuel bed, thereby intensifying the furnace draft and also reducing the air through the fuel bed.

d. Added moisture conglomerates the fine particles in the coal, thereby permitting a freer passage of air.

Discussing these theories in the order listed, it must be admitted that water added to coal entails a loss of the heat necessary to vaporize and superheat this water up to the temperature of the exit gases from the boiler. This item, however, is relatively small, usually being about 0.1 per cent for each 1 per cent of water in the coal fired. With many coals the improvement in capacity and in quality of ash are so marked that the fractional percentage of heat lost due to vaporizing the water is inconsequential.

In order to investigate the theory that moisture penetrates the coal and the steam formation bursts the pieces open, 12 pieces of Indiana coal were put in a drier at 90 deg. temperature for 48 hr. Twelve more pieces were put into hot water. This water was renewed by hot water twice during the 48 hr.

Two pieces of almost equal size, one from the drier the other from the water, were laid on an asbestos pad and put into an electric furnace, heated to a temperature of 1850 deg. F. The instant the pieces entered the furnace, a very thin scale was seen to fly from the wet piece, but the dry piece gave flame before the wet piece. This operation was repeated several times, each time selecting pieces as near the same size and shape as possible. Each time the scale, probably 0.01 in. in thickness, was seen to fly from the wet piece, but invariably the dry piece caught flame first. These particles were put under a four-powered glass to see if the moist piece was any more broken up than the dry piece, but no difference in construction could be noted.

This test was made to test the theory that the moisture inside the coal, when suddenly going to steam, has an explosive action, thus making the coal more porous and permitting the entrance of oxygen for combustion. All indications of this test disproved the theory.

In order to study the effect of moisture in coal on air flow, samples of coal were put into a draft chamber as shown in Fig. 1, and moisture added to note the effect on the air flow. The apparatus in Fig. 1 consisted of a chamber A made of a section of pipe. The fuel was supported on a screen. The chamber was put under a pressure less than atmosphere by an air siphon B. An anemometer was inserted at M and a draft gage at C.

Test No. 1:

In this test, a sun-dried sample of screenings 6 in. deep was put into the chamber A. The draft was varied over a range from 0.10 in. to 0.50 in. and the corresponding air velocities noted. The result of this series of readings is plotted on Curve I, Fig. 2. No attempt was made to translate the air velocities into cubic feet per minute, as the results are relative since the inlet area is constant.

* Chief Engineer, Green Engineering Co.

Test No. 2:

For this test the coal sample was moistened moderately and the same range of drafts and velocities recorded. These results are plotted on Curve III, Fig. 2.

Test No. 3:

This test consisted in saturating the coal sample with water and taking a similar series of readings. These results are shown on Curve II, Fig. 2.

It will be noted that air flows more freely through moderately moist coal than either saturated or dry coal, and that dry coal offers the greatest resistance to air flow. No effort was made in these tests to determine the amount of moisture in the samples.

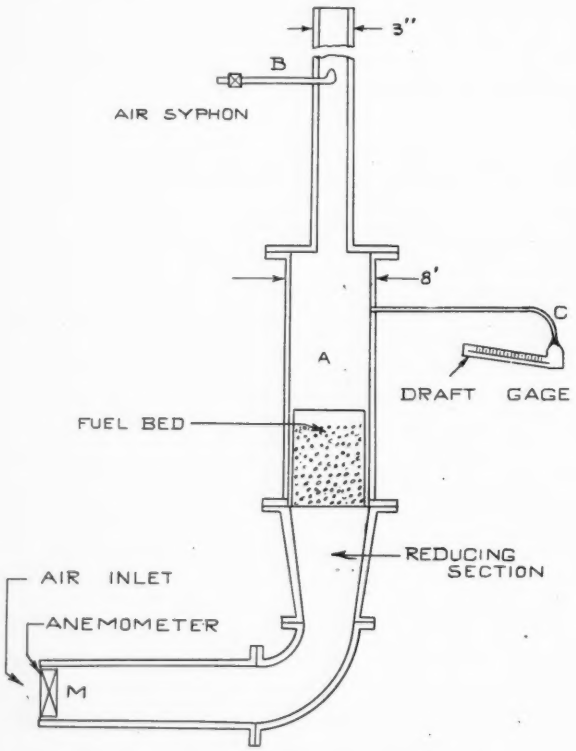


FIG. 1. APPARATUS USED TO DETERMINE AIR FLOW THROUGH GREEN COAL BED AT VARYING DRAFTS AND MOISTURE CONTENTS

In order to determine more closely this point of minimum resistance to air flow, a 35-lb. sample of sun-dried Illinois coal was taken, using a 6-in. fuel bed, at a constant draft intensity of 0.30 in. This sample was kept in the closed container and the added moisture was thoroughly mixed through the coal and given 10 min. for absorption. Water was added to this sample in increments of 2 lb. Starting with the dry samples as a zero surface moisture, this gave increments of approximately 5.0 per cent, 10.0 per cent, 14.5 per cent. The results are shown in Fig. 3, curve I. This curve is seen to follow the general outline expected from the previous tests.

In order to get a smaller increment of moisture content, a similar 35-lb. sun-dried sample was taken and water added in increments of 1 lb. per test. This gave a surface moisture content of approximately 2.5, 5, 8.0, 10.0 and 12.5 per cent. These results are shown on curve II, Fig. 3. The minimum air resistance occurred at an added moisture content of 7.5 per cent. Referring to curve II, Fig. 3, it will be noted that with a constant draft there is a variation in air flow through the fuel bed, amounting to a 55 per cent increase in moist coal, as compared to dry coal, and 20 per cent increase for wet coal compared to dry coal.

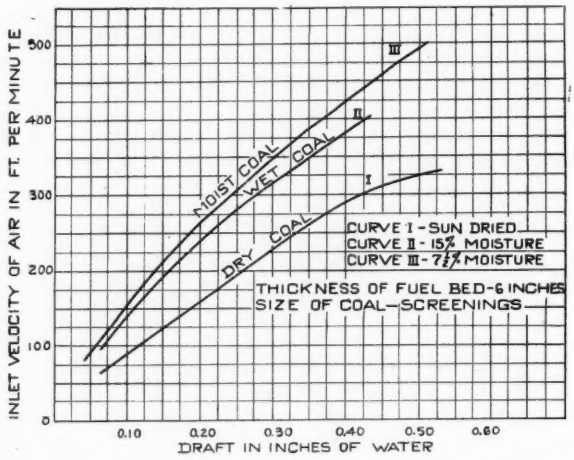


FIG. 2. VARIATION OF AIR FLOW THROUGH COAL BED WITH DIFFERENT DEGREES OF MOISTURE AND INTENSITY OF DRAFT

These tests afford a very definite explanation of the reason for higher combustion rates and increased boiler capacity obtainable with moist or properly tempered coal.

Conclusions that may be reached from this study are:

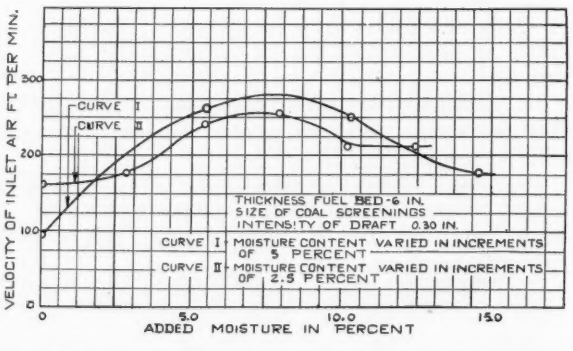


FIG. 3. AIR FLOW THROUGH BED OF GREEN FUEL AT VARYING MOISTURE AND CONSTANT DRAFT

1. Added moisture is beneficial with many coals, certainly with most Western coals.

2. Properly tempered coal has less resistance to air flow than either very wet or very dry coal.

3. Very wet coal has less resistance to air flow than very dry coal.

4. The theory of steam formation cracking open pieces of coal does not seem to be correct.

5. Properly tempered Western coal burns much more rapidly than coal either too wet or too dry.

6. Properly tempered coal burns to a cleaner ash by

decreasing the fuel bed resistance, thereby reducing the burning of holes in the fuel bed.

7. Properly tempered coal causes less siftings than dry coal, therefore fewer holes occur in the fuel bed and less coal has to be re-handled.

Knowing therefore that the advantages of adding moisture to many coals far more than outbalance the disadvantages, and having the above brief study of the action of moisture on air flow, we can give some thought to how best to add moisture or temper coal.

On this subject we can at present only make some general observations, based on the experience of many plants with a great variety of coals. Such observations are:

a. Moist coal such as obtained when a car of coal has been rained on the previous day, is usually well tempered. (Substantiated from Fig. 3.)

b. Extremely wet coal does not burn as well as coal with medium moisture. (Substantiated from Fig. 3.)

c. Moisture added an hour or two before burning is more beneficial than moisture added in stoker hoppers.

d. The most usual place to temper coal is at the crusher or in the conveyor. The moisture then has time to mix thoroughly with the coal and agglomerate the fine particles.

e. With Western coals, one of the important features of plant operation is tempering the coal. With a known coal, intelligent firemen soon become expert in judging the best amount of moisture for proper tempering. This varies with different coals and with coal sizes.

f. Exhaust steam for tempering purposes gives very satisfactory results and is used quite extensively.

Sizing of coal, discussed in an article in the Feb. 1 issue, and tempering of coal, are important factors in obtaining good results. No station or combustion engineer can afford to overlook them. Stations getting best results have studied their problem and have developed a system of sizing and tempering their coal.

Analysis of Cooling Tower Performance

FUNDAMENTAL PRINCIPLES UNDERLYING THE ACTION OF THE COOLING TOWER ARE DISCUSSED; USE OF PSYCHROMETRIC CHART DEMONSTRATED. BY J. W. GAVETT, JR.*

WHEN a power plant is not located on a river or lake from which it may draw a continuous supply of fresh circulating water for its condensers, recourse must be had to some device for cooling the water so that it may be used over and over again. This cooling may be accomplished in three different ways:

a. By a simple cooling pond, into which the warm water is pumped and from which it is drawn after being cooled. Cooling is obtained by evaporation and conduction from the surface of the pond.

b. By a spray pond, a refinement of the simple pond in which the surface of the pond is largely replaced by the surfaces of myriad drops of water projected from spray nozzles. It is evident that the spray pond may be much smaller than the simple pond but that it requires additional expenditure for piping and nozzles.

c. By a cooling tower, a wooden or metal structure in which a descending current of warm water is brought into intimate contact with an ascending current of air. There are many different designs of cooling towers, but in general they all resemble a short chimney or stack of large cross section, the sides being open or closed according to the particular design. The air is drawn in at the bottom by natural or mechanical draft, while the water is pumped to the top of the tower and allowed to trickle down over an internal structure designed to divide minutely the stream and thus expose a maximum surface to the air.

HUMIDITY

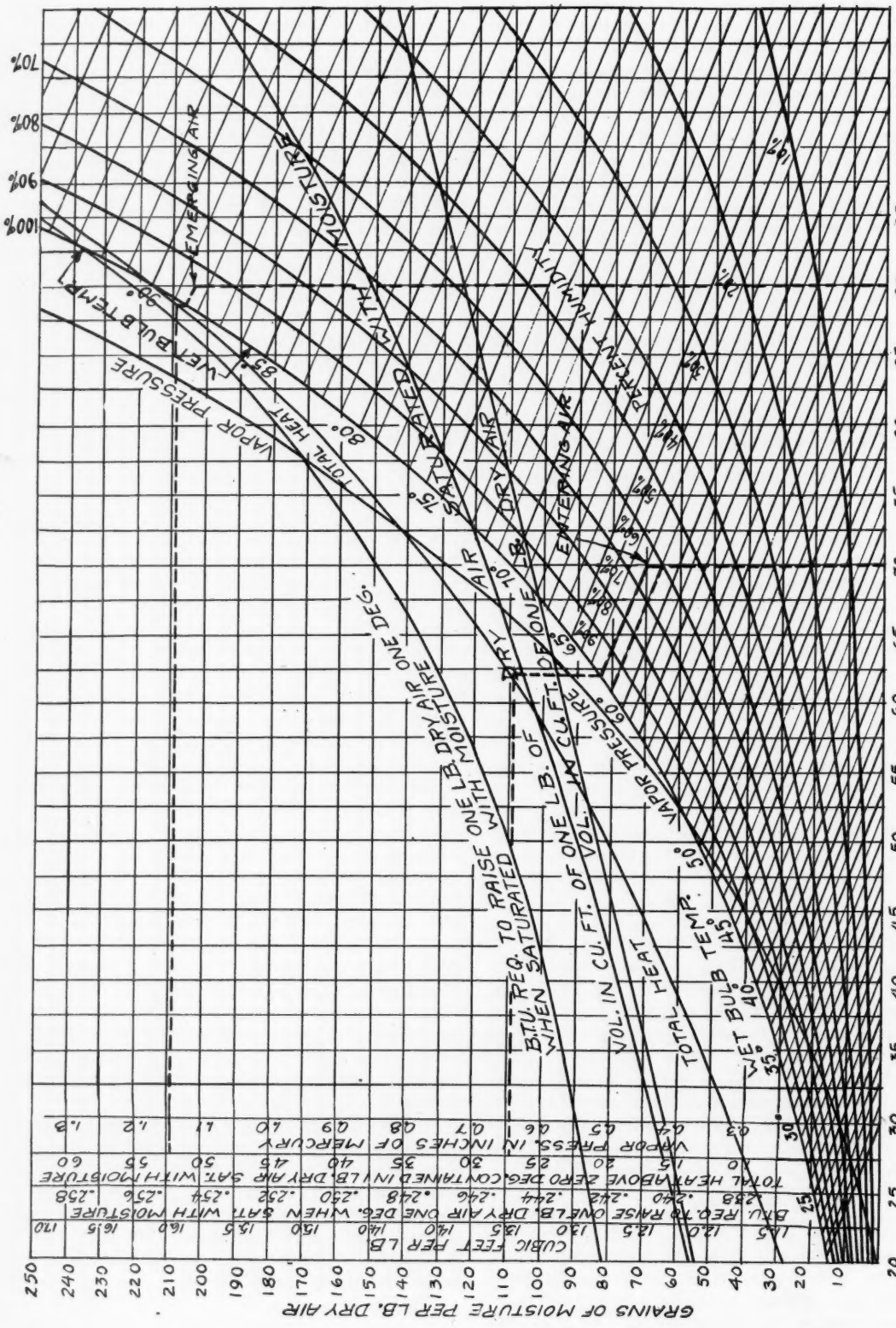
IT IS a familiar fact that the atmosphere contains water vapor to which is given the name of humidity. The behavior of this vapor under various conditions of temperature and pressure is the most important factor in the functioning of the cooling tower. The total pressure of the mixture of air and vapor is measured by the barometer and is what we know as the barometric or atmospheric pressure. But from Dalton's Law of Partial Pressures we also know that this barometric pressure is the sum of the partial pressure of the air and that of the water vapor it contains, each substance acting as if the other were absent. The partial pressure of the vapor is never more than a very small fraction of the total pressure. The ability of air to absorb moisture depends on its temperature, increasing as the temperature rises.† At any given temperature, if the air contains all the moisture it can hold, it is said to be saturated, and the vapor is also saturated.

As used here the term "saturated" has exactly the same meaning as when it is used in connection with steam in boiler or engine work; that is, the vapor contained in saturated air is dry and saturated steam and its partial pressure is the saturation pressure corresponding to its temperature. If the air contains less than the maximum weight of moisture, the degree of saturation is called the relative humidity and is expressed as a percentage. The partial pressure and the weight of moisture present bear this percentage relation to the respective values at saturation. Evidently then, the moisture in unsaturated air is in reality superheated steam, since it exists at a temperature higher than the saturation temperature corresponding to its partial pressure.

Vapor content of unsaturated air will be increased by the evaporation of any water with which it may come into contact. In other words, the vapor tends to become saturated. This tendency makes possible a simple and accurate method of measuring the degree of saturation or relative humidity. The device used for this purpose is called a psychrometer, a name derived from the Greek word psychros, meaning cold, and applied here in view of the fact that the instrument

*Professor of Mechanical Engineering at the University of Rochester.

†That air "absorbs" water vapor is an expression which is sanctioned by general usage, but is not strictly accurate. It would be more accurate to say that space holds the vapor, since its state would be unchanged if all the air were removed. Only as regards heat interchanges and temperature are the air and moisture dependent on each other.



PSYCHROMETRIC CHART SIMPLIFIES CALCULATION OF COOLING TOWER PERFORMANCE

functions because of a cooling action. The psychrometer consists of two thermometers, either stationary or mounted on a swivel frame so that they can be whirled around. They are identical, except that the bulb of one is wrapped in a wick which is kept wet.

If the air surrounding the instrument is unsaturated, evaporation will take place from the wick, the heat necessary to vaporize the water being taken from the wick and the bulb of the thermometer, thus decreasing its temperature reading. This decrease in temperature below the reading of the other, or dry bulb thermometer, is called the wet bulb depression. Knowing the dry and wet bulb temperatures and having available a psychrometric chart, we can read the value of relative humidity. For example, let us assume dry and wet bulb temperatures of 70 deg. and 61 deg. respectively. Following the 70 deg. line vertically from the lower margin until it intersects the sloping 61 deg. line, we find the relative humidity to be 60 per cent, as indicated by the curved line. If the air were saturated, there would be no evaporation and the two bulbs would both indicate 70 deg. and the relative humidity would be 100 per cent.

Having determined the relative humidity for the given conditions, it remains to find the actual weight of water vapor present in a cubic foot, or accompanying a pound, of dry air. Following the same example a little further, we can find from steam tables that a cubic foot of dry and saturated steam at 70 deg. weighs 0.001,148 lb. Remembering that the relative humidity is a measure of the degree of saturation, it is evident that the actual weight of moisture existing in each cubic foot is

$$0.001{,}148 \times 0.60 = 0.000{,}688{,}8 \text{ lb.}$$

Similarly, since the saturation pressure corresponding to 70 deg. is 0.739 in. of mercury, the actual partial pressure of the vapor is

$$0.739 \times 0.60 = 0.4434 \text{ in. of mercury.}$$

But we know that the barometric pressure, which we will assume to be 29.92 in., is the sum of the pressures of air and vapor. The actual partial pressure of the air is then

$$29.92 - 0.44 = 29.48 \text{ in.}$$

This enables us to find the density of the dry air. Taking the standard density as 0.0807 lb. per cu. ft. at 29.92 in. and 32 deg., we have,

$$0.0807 \times \frac{32 + 460}{70 + 460} \times \frac{29.48}{29.92} = 0.0737 \text{ lb. per cu. ft.}$$

The specific volume will be

$$\frac{1}{0.0737} = 13.57 \text{ cu. ft. per lb.}$$

Thus each pound of dry air will contain

$$13.57 \times 0.000{,}69 = 0.009{,}37 \text{ lb. of vapor}$$

It is common practice to express this weight in grains (1 lb. = 7000 gr.). Expressed in this way, it becomes

$$0.009{,}37 \times 7000 = 65.59 \text{ gr. per lb. dry air.}$$

If this is expressed in grains per cu. ft. of dry air it is defined as the absolute humidity, and in this case would be

$$0.000{,}69 \times 7000 = 4.83$$

Cooling by Evaporation

When any liquid evaporates, each unit weight must receive from its surroundings a certain number of heat units, the number varying for any given liquid with its temperature and pressure. This quantity of heat is called the latent heat of vaporization, and it may be drawn from other portions of the same liquid or from nearby bodies. In any case, there is a decrease in temperature of the source of heat (except in the special case of the vacuum pan, which we need not consider here). The simplest demonstration of this fact is the sensation of cooling experienced when the skin is wet with some volatile liquid like alcohol or gasoline.

Thus when partially saturated air enters a cooling tower and comes into contact with water, evaporation of a part of the water takes place and heat is drawn from the remainder. As the air rises through the tower, its temperature increases due to conduction of heat from the warmer water. Its capacity for moisture therefore increases and evaporation continues, until at the top of the tower the air is nearly or completely saturated, and its temperature is only a few degrees below that of the incoming water. The small amount of vapor originally in the entering air has had its temperature raised with that of the air.

We can now summarize the agencies which remove heat from the water as follows:

(a) the evaporation of a portion of the water.

(b) the addition of sensible (temperature raising) heat to the air.

(c) the addition of sensible heat to the vapor in the air. This item is very small and may be neglected.

(d) Agencies other than the action of the air. This includes principally radiation from piping between condenser and tower and from the walls of the tower. This item is either neglected in computations or a guess is made as to what per cent of the total heat is removed in this way.

Calculation of Air Requirements

To illustrate the principles which have been discussed, it will be best to work out the numerical calculation of a hypothetical case, in which it is required to find the volume of air which must pass through a cooling tower per unit time to accomplish a certain desired amount of cooling.

It is assumed that the tower is to serve a condensing turbo-generator unit carrying an average load of 1500 kw. with a water rate of 18 lb. per kw.-hr. Steam is supplied at 125 lb. per sq. in. abs. and 100 deg. superheat at the throttle, and it is desired to maintain an average vacuum of 27 in. referred to 29.92 in. barometric pressure.

Local weather reports covering several years indicate than an average outdoor tempeature of 70 deg. and an average humidity of 65 per cent may be expected. This fixes the average temperature to be expected of the water leaving the tower at about 80 deg. Although under exceptional conditions of very low humidity it is possible to cool the water below the temperature of the air, it is not safe in general to expect cooling better than to a temperature about 10 deg. above that of the air. The temperature corresponding to the desired vacuum is 115 deg., and assuming a good condenser, the

discharge water will have a temperature of 100 deg. and the condensate of 110 deg.

In a well designed tower it is possible for the air to emerge completely saturated, but for safety the relative humidity of the emerging air will be taken as 95 per cent, and its temperature as 10 deg. below that of the entering water or 90 deg.

For the sake of clearness these various assumptions will be summarized before beginning the calculations.

Load on turbine	1500 kw.
Water rate	18 lb. per kw.-hr.
Steam pressure at throttle	125 lb. per sq. in. abs.
Superheat at throttle	100 deg.
Vacuum in condenser	27 in.
Barometer	29.92 in.
Temperature of condensate	110 deg.
Temperature of injection water	80 deg.
Temperature of discharge water	100 deg.
Temperature of outside air	70 deg.
Temperature of air leaving tower	90 deg.
Relative humidity of outside air	65 per cent
Relative humidity of air leaving tower	95 per cent

Each step in the ensuing calculations will be lettered to facilitate reference and the caption of each item will indicate the quantity sought. Calculations are carried out to three and four places which is sufficiently accurate for practical purposes.

(a) Heat to be removed from exhaust steam in condenser per hour

Total heat in throttle steam above condensate temperature

$$1245 - 110 + 32 = 1167 \text{ B.t.u. per lb.}$$

Heat converted to work in turbine

$$\frac{3413}{18} = 190 \text{ B.t.u.}$$

Heat to be removed per hour

$$(1167 - 190) \times 1500 \times 18 = 26{,}380{,}000 \text{ B.t.u.}$$

This quantity is evidently also the heat which must be removed from the circulating water if it is to be used again.

(b) Quantity of circulating water used per hour

Temperature range of circulating water

$100 - 80 = 20$ deg. or 20 B.t.u. removed per lb. of water.

Weight of water

$$\frac{26{,}380{,}000}{20} = 1{,}319{,}000 \text{ lb. per hour, or}$$

$$\frac{1{,}319{,}000}{8.35 \times 60} = 2630 \text{ gal. per minute.}$$

(c) Partial pressure of vapor in entering air

Saturation pressure at 70 deg. = 0.739 in. of mercury

Partial pressure at 65 per cent humidity

$$0.739 \times 0.65 = 0.48 \text{ in.}$$

(d) Partial pressure of dry air entering

$$29.92 - 0.48 = 29.44 \text{ in.}$$

(e) Density of dry air entering

$$0.0807 \times \frac{32 + 460}{70 + 460} \times \frac{29.44}{29.92} = 0.0736 \text{ lb. per cu. ft.}$$

(f) Weight of 1000 cu. ft. of entering air

$$0.0736 \times 1000 = 73.6 \text{ lb.}$$

It is customary to deal with units of 1000 cu. ft. to avoid the use of very small decimals.

(g) Weight of vapor in 1000 cu. ft. of entering air

Density of saturated steam at 70 deg. = 0.001,148 lb. per cu. ft.

Weight of vapor per 1000 cu. ft. at 65 per cent humidity

$$0.001{,}148 \times 0.65 \times 1000 = 0.746 \text{ lb.}$$

(h) Partial pressure of vapor in air leaving tower (see item e)

$$1.417 \times 0.95 = 1.35 \text{ in.}$$

(i) Partial pressure of dry air leaving (see item d)

$$29.92 - 1.35 = 28.57 \text{ in.}$$

This calculation assumes no change in total pressure between bottom and top of the tower. This is not strictly accurate, but the error introduced is too small to be considered.

(j) Density of dry air leaving (see item e)

$$0.0807 \times \frac{32 + 460}{90 + 460} \times \frac{28.57}{29.92} = 0.069 \text{ lb. per cu. ft.}$$

(k) Volume of each 1000 cu. ft. of entering air upon emergence

From items (e) and (j) we see that the air leaving the tower is less dense than when it entered. Therefore each 1000 cu. ft. entering will emerge with a volume of

$$1000 \times \frac{0.0736}{0.069} = 1066 \text{ cu. ft.}$$

(l) Weight of vapor carried out of tower by each 1000 cu. ft. of entering air (see item g)

$$0.002{,}13 \times 0.95 \times 1066 = 2.157 \text{ lb.}$$

(m) Weight of water evaporated per 1000 cu. ft. of air (see item l, item g)

$$2.157 - 0.746 = 1.411 \text{ lb.}$$

(n) Heat removed by evaporation

Although the evaporation takes place at various temperatures, all the vapor eventually reaches a temperature of 90 deg. It is consequently a close, but not strictly accurate, assumption to use the heat of vaporization corresponding to 90 deg., which is 1041 B.t.u. per lb. Therefore the heat removed by evaporation per 1000 cu. ft. of air is

$$1.411 \times 1041 = 1470 \text{ B.t.u.}$$

(o) Heat removed in raising the temperature of the air

Each 1000 cu. ft. of air, weighing 73.6 lb. (item f) is heated from 70 to 90 deg. Since the specific heat of air is 0.24, the heat removed in this way is

$$73.6 \times 0.24 \times (90 - 70) = 353 \text{ B.t.u.}$$

(p) Heat removed in heating vapor in entering air

By a process similar to that of item (o) this is

$$0.746 \times 0.46 \times (90 - 70) = 6.85 \text{ say } 7 \text{ B.t.u.}$$

(q) Total heat removed per 1000 cu. ft. of air

	B.t.u.	Per cent
By evaporation	1470	80.30
Raising temperature of air	353	19.31
Heating vapor	7	.39
	1830	100.00

Item (p), heat to the vapor in entering air, has been calculated only to prove that it is insignificant and can always be neglected. The relative importance of the other two items will vary with weather conditions. In rainy or foggy weather the heating of the air must account for all of the cooling of the water since no evaporation can take place, the air being initially saturated. In very dry weather evaporation will remove an even larger proportion of the heat than in this case.

(r) Total air required per hour

Referring now to item (a) and dividing it by the total in item (q) and multiplying by 1000 we find the cu. ft. of air necessary per hour.

$$\frac{26{,}380{,}000}{1830} \times 1000 = 14{,}372{,}000 \text{ cu. ft.}$$

(s) Make up water required per hour

Water which is evaporated is, of course, lost. Therefore the quantity of make up required will be (see item m)

$$\frac{14{,}372{,}000}{1000} \times 1.411 = 20{,}300 \text{ lb. per hour, or}$$

$$\frac{20{,}300}{8.35 \times 60} = 40.5 \text{ gal. per min.}$$

This quantity will usually be slightly higher than shown by calculation owing to leaks in the circuit.

Such calculations as have just been given are too long and cumbersome for use where a number of problems are to be solved, although they serve their purpose as an analysis of what actually happens in the cooling tower. It is now proposed to show how the solution of the problem may be greatly shortened and simplified by the use of the psychrometric chart shown herewith. This chart is due to W. H. Carrier and the details of its derivation may be found in the Transactions of the A. S. M. E. vol. 33, 1911, page 1005.

It should be noted that the chart is plotted for a barometric pressure of 29.92 in. It can be used without serious error for other ordinary atmospheric pressures, but should be corrected for high altitude work where there is a serious difference in barometer reading.

This method of solution will be applied to the same problem as given above. Items (a) (c) (d) (e) and (f) must be computed as already shown, but the rest of the calculations are eliminated.

First locate the state point of the entering air. This is done by finding the intersection of the 70 deg. dry bulb temperature line and the 65 per cent humidity line. This is shown at point x on the chart and indicates a wet bulb temperature of 62 deg. Following the 62 deg. line to its intersection with the saturation curve or line of 100 per cent humidity, thence vertically to the line marked Total Heat, and reading on the Total Heat scale at the left, we find that each pound of entering air has a heat content of 27.3 B.t.u. above zero degrees. Applying a similar process to the emerging air the heat content is found to be 52.3 B.t.u. Each pound of air with its contained and acquired moisture takes up $52.3 - 27.3 = 25$ B.t.u. in passing through the tower. The weight of air required will evidently be $\frac{26{,}380{,}000}{25} \times 1{,}055{,}000$ lb. per hour. From items (e) and (f) we know that the weight of entering air is 73.6 lb. per 1000 cu. ft. The volume required is therefore $\frac{1{,}055{,}000}{73.6} \times 1000 = 14{,}337{,}000$ cu. ft. per hour. This result checks the mathematical calculations within the degree of accuracy obtainable in reading the chart.

High Pressure and Temperature Steam Lines*

Results of Tests on Heat Radiation Losses from Pipe Lines Carrying Superheated Steam. By B. N. Broido

ONE OF the phases in which engineers, power plant operators and managers are interested at the present time is that of conducting superheated steam through pipe lines. The recent tendency in plant design, particularly large plants, is toward high pressures and high temperatures. A study of the losses of heat and pressure in pipe lines carrying highly superheated and high pressure steam at the present time will aid the designer in dimensioning such lines, for very little has been published on the subject in this country.

This field, naturally, is a large one and in the original paper the discussion was carried on under four main divisions, as follows:

a. Radiation losses in pipe lines carrying superheated steam.
b. Resistance to the flow or pressure drop of superheated steam in pipe lines.
c. The most advantageous steam velocity, particularly for high pressure lines; and
d. Other features to be taken in consideration in designing pipe lines for transmission of superheated steam of either low or high pressures.

In this abstract, however, only the first subject will be considered as it is probably one of the most important.

Radiation Losses in Pipe Lines Carrying Superheated Steam

It has been the author's privilege to have had an opportunity to study this subject and to examine the results of tests conducted in Europe in which actual superheated steam was used, particularly the tests made by Dr. Bernard and Herr Eberle of Magdeburg and Munich, respectively.

In Munich the tests were conducted with a pipe line about 100 ft. long, 3 in. in diameter, one part of which—about 80 ft. in length—could be replaced by a pipe about 6¼ in. in diameter. In order to determine the radiation losses in a pipe line, it is necessary to know the amount of steam condensed in the

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line. A few preliminary tests showed that with increased velocity of the steam the amount of water separated became low, which demonstrated conclusively that ordinary separators do not remove all the water from the steam, even at low velocities, and the higher the steam velocity, the less reliable the separators.

It was therefore decided to conduct all saturated steam tests by connecting one end of the line to the

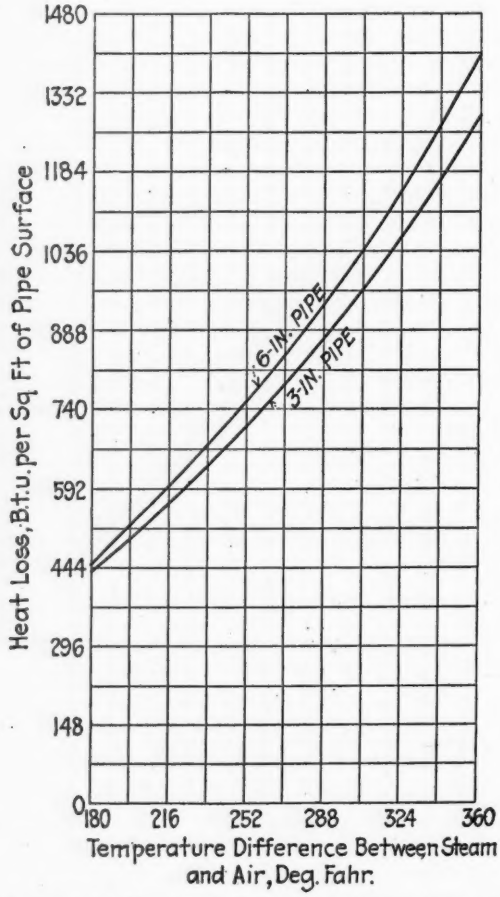


FIG. 1. HEAT LOSSES FROM BARE PIPE—SATURATED STEAM

boiler and closing the other end, so that when the line was once filled with steam there would be no additional flow except the makeup for condensation, and the steam would be practically at rest in the pipe. Readings were taken only after it was found that the pipe wall and the covering had reached and maintained their final temperature. With saturated steam it required from 1½ to 2 hr. to attain a steady temperature. With superheated steam about 4 hr. was required.

In Fig. 1 curves are plotted showing how the radiation losses per square foot of pipe surface vary with the temperature difference between the steam and the outside air, while Fig. 2 shows how the coefficient of heat transfer per square foot of radiating surface per degree temperature difference per hour depends upon the steam temperature. It is an interesting fact that by inserting the values obtained in the tests in the formula for the total heat-transmission, coefficient K, based on the well-known formula of Stefan-Boltzmann for the heat radiated from a black body, namely

$$K = k + \frac{c}{t_w - t_a}\left\{\left(\frac{t_w + 460}{100}\right)^4 + \left(\frac{t_a + 460}{100}\right)^4\right\}$$

this coefficient corresponds very closely with that obtained by the results when the value of k, or the heat-

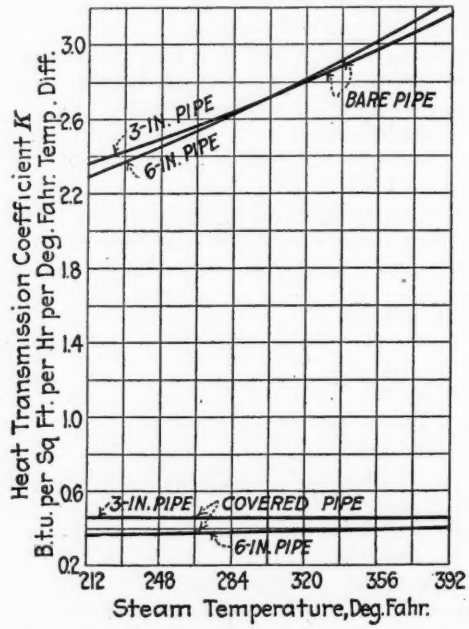


FIG. 2. HEAT TRANSMISSION COEFFICIENT K OF A BARE AND COVERED PIPE—SATURATED STEAM

transmission coefficient for convection, is taken as 2.2, which may reasonably be assumed to be correct. This shows that the Stefan-Boltzmann formula is reliable and can be safely used for similar calculations.

Effect of Velocity Upon Heat Transmission

In view of the fact that the velocity of superheated steam doubtless has an influence upon the heat trans-

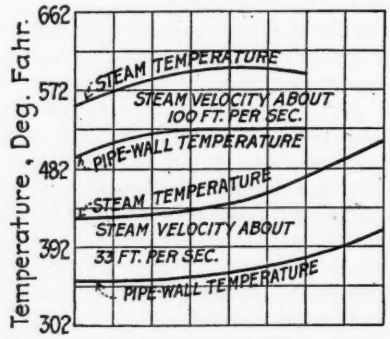


FIG. 3. INFLUENCE OF STEAM VELOCITY ON THE PIPE WALL TEMPERATURE

mission, tests were conducted with different velocities. The results of tests conducted with bare pipes were highly impressive. At a velocity of about 100 ft. per sec. and steam temperatures of 291 to 300 deg. C. (556 to 734 deg. F.) corresponding to 221 and 399 deg.

superheat, the temperature difference between the steam and pipe wall was 34 deg. while the heat transmission coefficient was 35. With steam velocities of 33 ft. per sec., the difference between the steam and the pipe wall temperatures was greater. At the lower steam temperatures of 220 to 267 deg. C (428 to 513 deg. F.), the temperature difference was 45 to 65 deg. C. (86 to 122 deg. F.) and the heat-transmission coefficient was 16. By decreasing the velocity of the steam one-third, the coefficient of heat transmission between superheated steam and the pipe wall was decreased to one-half of the first value. This indicates clearly that the behavior of superheated steam is different from that of saturated steam as far as imparting heat to a metallic wall is concerned, which is due to the fact

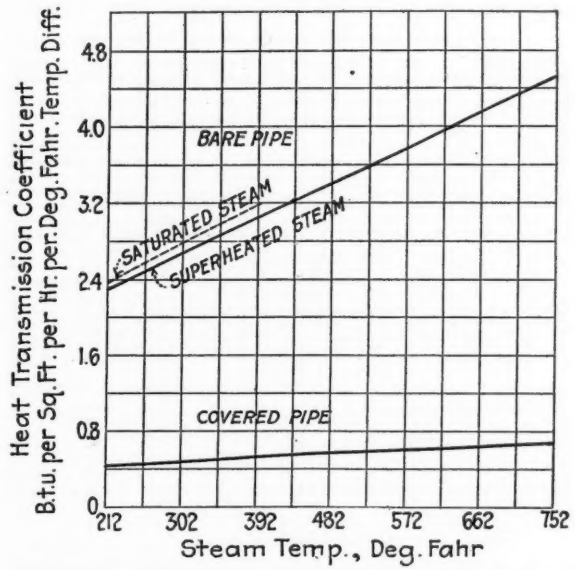


FIG. 4. HEAT TRANSMISSION COEFFICIENT K OF A BARE AND COVERED PIPE—SATURATED STEAM

that saturated steam, in transferring heat to the pipe wall, partly condenses or gives up some of its latent heat, which heat is not as closely combined with the steam as the sensible heat of a liquid or the heat of superheat. This fact often is not understood, even by technical men.

While the results of the tests with bare pipe—particularly the variation of the heat-transmission coefficient at different temperatures and velocities—are not important in connection with pipe lines which invariably are insulated, they are of considerable interest as far as the use of superheated steam for heating and drying purposes is concerned.

The experiments demonstrate that the heat-transmission coefficient increases considerably with the increased velocity and also that the wall temperature depends not only upon the steam temperature but also upon its velocity. The results are presented graphically in Fig. 3.

While in the tests with saturated steam the steam temperature remained practically constant for the entire length of the pipe, when superheated steam is flowing through a pipe its temperature decreases. The temperature difference was taken into consideration in the values given. Figure 4 gives the heat-transmission coefficients for bare and covered pipe of about 3 in. diameter, for steam temperatures from 220 to 291 deg. C. (428 to 528 deg. F.) figured from the test results, while Fig. 5 gives the curve of the heat loss in B.t.u.

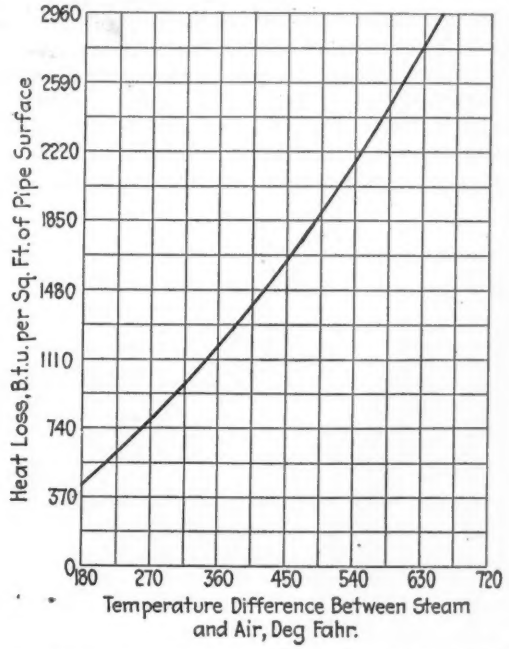


FIG. 5. HEAT LOSS FROM BARE PIPE—SUPERHEATED STEAM

Experiments were also conducted with a pipe line approximately 6 in. in diameter and with superheated steam. The results were entirely identical with those of

VARIATION OF HEAT LOSSES, HEAT TRANSMISSION COEFFICIENTS FOR BARE AND COVERED PIPES—SUPERHEATED STEAM

Temperature difference between steam and air, deg. fahr.	Heat loss per square foot of outside pipe surface per hour		Saving through the covering, per cent	K	
	Bare pipe, B.t.u.	Covered pipe, B.t.u.		Bare pipe, B.t.u.	Covered pipe, B.t.u.
212	453	78.5	82.7	2.80	0.43
257	606	103.2	83.0	2.67	0.45
302	773	130.2	83.2	2.83	0.48
347	971	160.5	83.5	3.06	0.51
392	1184	192.4	83.7	3.26	0.53
437	1394	225.2	83.8	3.43	0.55
482	1637	260.8	84.1	3.63	0.57
527	1909	303.4	84.1	3.85	0.60
572	2192	344.1	84.3	4.04	0.63
617	2497	384.8	84.6	4.22	0.65
662	2804	429.2	84.7	4.43	0.67
707	3135	478.7	84.7	4.61	0.70
752	3149	529.8	84.8	4.81	0.73

the smaller pipe, which proves that the calculation is reliable and that the heat radiation losses, contrary to the general belief, are little influenced by the diameter of the pipe.

In order to determine accurately the influence of temperature, velocity, or other varying conditions upon the losses, laboratory tests are usually conducted in enclosed rooms with the air practically still, while in actual practice the velocity of the air also has considerable influence upon the heat radiation. The tests showed that with the bare pipe the difference in temperature between the superheated steam and the pipe wall is considerable. It is less, however, with covered pipes, and the more efficient the covering or the less the

heat radiated from the pipe, the lower is the difference between steam and wall temperature. The higher the velocity of the air around the pipe the more heat is radiated, and the greater the difference between the amount of heat radiated with saturated and with superheated steam. In practice the covering is seldom perfect, particularly that of the flanges, which are often neglected. If the pipe-wall or flange temperatures are lower than the temperature of the steam, the radiation is naturally reduced. Observations of long outside pipe lines have shown that the actual radiation losses at an average air velocity of about 5 ft. per sec. are about 15 per cent to 30 per cent for saturated steam, and for superheated steam from 10 per cent to 20 per cent higher than the laboratory tests.

While from the tests one would conclude that the direct radiation losses for superheated steam are not appreciably lower than those of saturated steam of the same temperature, there are, however, a few other points to be considered in estimating the relative advantages of the two so far as their transmission through pipe lines is concerned. With saturated steam any heat radiated causes a part of the steam to be condensed, and the condensate, particularly for long pipe lines, is not returned to the boiler but is discharged through traps and wasted, so that in addition to the direct heat lost by radiation there is a further loss of the liquid heat of the condensate, which in some cases, particularly for high-pressure steam, may amount to 25 per cent of the radiated heat. With superheated steam the heat lost only decreases the temperature and no condensation occurs as long as the steam remains superheated, so that no additional heat besides that radiated is wasted.

Another important fact to be considered in connection with superheated steam is that a considerably higher velocity in the pipe lines is permissible. The velocity of the steam in a pipe, or the size of the pipe, is usually determined by the maximum friction loss or pressure drop which can be allowed. Due to the low pressure drop and high velocity possible with superheated steam, a greater amount of steam can be transmitted with the same pipe, so that the radiation losses per unit weight are less. Therefore, in order to make a fair comparison between the radiation losses in carrying superheated and saturated steam, not the direct heat should be considered, but the total heat losses in percentage of the heat conveyed in the steam through the pipe.

Wall Thickness of Internal Pressure Pipes

CONVENIENT FORMULA AND CONSTANT USED IN FIGURING STRESSES. BY FRED WM. BOSCH

IN THE table presented herewith is given for convenient reference a "constant c," which is part of a simplified formula, and will be found useful to those called upon to calculate the wall thickness, stress in wall or allowable working pressure of pipes and cylinders subjected to internal pressure, and the range of the table covers all ordinary conditions most generally met with.

CONSTANT C USED IN FORMULA FOR CALCULATING WALL THICKNESS OF PIPES AND CYLINDERS

Kt in Lb. Per Sq. In.	Pi in Lb. Per Square Inch																					
	100	125	150	175	200	250	300	400	500	600	700	800	1000	1250	1500	2000	2500	3000	4000	5000	7500	10,000
1,200	.038	.048	.060	.071	.084	.104	.138	.207	.298	.426	.631	1.041										
1,400	.032	.041	.050	.059	.070	.090	.113	.165	.230	.314	.426	.592	1.620									
1,600	.028	.035	.044	.051	.060	.077	.096	.139	.189	.250	.326	.426	.791									
1,800	.025	.031	.038	.045	.052	.068	.084	.118	.160	.207	.265	.335	.549	1.31								
2,000	.022	.028	.034	.040	.047	.060	.074	.104	.138	.177	.224	.278	.426	.791								
2,200	.021	.026	.031	.036	.042	.054	.066	.093	.123	.156	.194	.237	.350	.583	1.175							
2,500	.017	.022	.027	.032	.036	.047	.057	.080	.104	.131	.161	.195	.277	.426	.725							
2,700	.016	.020	.024	.029	.033	.042	.051	.071	.092	.116	.141	.170	.237	.350	.523	1.93						
3,000	.015	.019	.022	.026	.030	.038	.047	.064	.084	.104	.126	.151	.207	.297	.426	1.041						
3,500	.012	.016	.019	.022	.025	.033	.039	.054	.070	.086	.104	.123	.166	.230	.313	.593	1.621					
4,000	.011	.014	.017	.019	.022	.028	.034	.047	.060	.074	.088	.104	.138	.189	.299	.426	.792					
4,500	.009	.012	.014	.017	.020	.025	.030	.041	.052	.064	.077	.090	.119	.160	.207	.335	.549	1.041				
5,000	.008	.011	.013	.016	.018	.022	.027	.037	.047	.057	.068	.079	.104	.138	.177	.277	.426	.687				
6,000	.007	.009	.011	.013	.015	.019	.022	.030	.038	.047	.055	.064	.083	.109	.138	.207	.298	.426	1.041			
7,500									.030	.036	.043	.050	.064	.083	.104	.151	.207	.277	.494	1.041		
8,500									.025	.032	.037	.044	.056	.072	.088	.128	.172	.226	.375	.646		
10,000									.022	.027	.032	.037	.046	.060	.074	.104	.138	.178	.277	.2	.3106	
15,000									.015	.018	.021	.024	.030	.039	.046	.064	.084	.104	.151	.207	.426	1.041

We designate:

Di = Inside diameter of pipe or cylinder,
Ri = Inside radius of pipe or cylinder,
Ro = Outside radius of pipe or cylinder,
c = "Constant,"
s = Wall thickness in inches,
Kt = Tension stress in lb. per sq. in. allowed in material,
Pi = Pressure in lb. per. sq. in.

According to "Hutte" as quoted by C. Bach we have the formula:

$$Ro = Ri \sqrt{\frac{Kt + 0.4\,Pi}{Kt - 1.3\,Pi}}$$

and as $s = Ro - Ri = c\,2Ri = c\,Di$, it follows:

$$s = Ri\sqrt{\frac{Kt + 0.4\,Pi}{Kt - 1.3\,Pi}} - Ri = Ri\left(\sqrt{\frac{Kt + 0.4\,Pi}{Kt - 1.3\,Pi}} - 1\right)$$

$$\frac{s}{Ri}\sqrt{\frac{Kt + 0.4\,Pi}{Kt - 1.3\,Pi}} - 1 = 2c$$

$$\frac{s}{2\,Ri} = \frac{s}{Di} = \tfrac{1}{2}\left(\sqrt{\frac{Kt + 0.4\,Pi}{Kt - 1.3\,Pi}} - 1\right) = c = \text{"Constant"}$$

This value "c" $= \frac{s}{Di}$ has been calculated for various conditions, namely, for internal pressures from 100 lb. per sq. in. to 10,000 lb. per sq. in. and for stresses in material from 1200 lb. per sq. in. to 15,000 lb. per sq. in., and is contained in the body of the accompanying table.

Although the use of the table presents no difficulty, its practical use will be demonstrated by means of examples.

Example: A cast-iron hydraulic press cylinder of 12 in. diameter is to be used for lifting a load of 70 T. Stress in cylinder wall not to exceed 3500 lb. per sq. in. What wall thickness is required?

12 in. diam. = 113.1 sq. in. piston area,
70 T. = 140,000 lb., which, divided by the piston area = 1240 lb. per sq. in.

Referring to the table, we do not find a column for the exact pressure of 1240 lb., and we either interpolate or take the nearest one to it according to judgment, in this case, of course, we use column headed by 1250 lb., which gives us for the allowable stress of 3500 lb. per sq. in., a "Constant" c = 0.230.

Therefore wall thickness $s = c \times Di = 0.230 \times 12 = 2\frac{3}{4}$ in.

Example: Wall thickness required for 24 in. steam cylinder, working pressure 200 lb. per sq. in. stress in material 1600 lb. per sq. in.

According to table c = 0.060; thickness $s = 0.060 \times 24$ 1.44 in. or practically 1½ in.

Example: A cast-iron cylinder or pipe, 15 in. diameter, wall thickness ⅞ in. is to be subjected to 175 lb. per sq. in. Find the stress in wall.

$$s = c \times Di; c = \frac{s}{Di} = \frac{\frac{7}{8}}{15} = 0.0583$$

Referring to table, we look in column headed by "175 lb." for the nearest value to 0.0583, which is 0.059, and accordingly stress Kt = 1400 lb. per sq. in.

Example: Find the safe working pressure for a cast-iron pipe or cylinder of 20 in. diameter and 1¼ in. wall thickness, stress not to exceed 1600 lb. per sq. in.

$$c = \frac{s}{Di} = \frac{1\frac{1}{4}}{20} = 0.0624$$

and referring to table we find in line, prefixed with "1600 lb.," the nearest value as 0.060 and accordingly Pi = 200 lb. per sq. in.

Exhaust Steam Utilization in Britain

As Supplementary to Super-Stations, Combination Central Heating and Electric Generating Stations Are Proposed. By C. H. S. Tupholme

HOW the exhaust steam from electric generating stations might be turned to useful purpose with the resultant economy in coal formed the subject of an address, which is given here in abstract form, by C. Ingham Haden, past president of the Institution of Heating and Ventilating Engineers, to the Institution of Electrical Engineers in Britain.

Approximately 5 per cent of the number of British thermal units in the coal is converted into electrical energy in connection with electric generating stations, but I believe that it is hoped in new large stations to improve this figure to 8 per cent. I am sure it is not generally known what colossal figures are involved in this matter, and what enormous waste is taking place in so many stations.

With the most up-to-date boiler plant, it is claimed that an efficiency of 80 per cent is obtained from the coal, assuming the calorific value of the coal to be 14,000 B.t.u., 20 per cent or 2800 B.t.u. is lost in the boiler, and 90 per cent of the remainder, or 10,080 B.t.u. in the generating plant; i. e. out of a total of 14,000 B.t.u., 2800 plus 10,080, or 12,800 B.t.u. are lost and only 1120 B.t.u. are converted into electrical energy; in other words, for every 100 T. of coal used in this way the heat equivalent to 92 T. is lost, and, as the approximate total used in generating stations in the United Kingdom is 10 million T. a year, the huge total of 9,200,000 T.

As the electric current is sold under statutory powers, we as users have to pay the proportional cost of all this heat in the price per unit, but that does not fully explain why the cost of the units is so high. In most generating stations condensing equipment is employed, with cooling towers if no other source of water is available. I believe that it is the general practice to employ electrically-driven pumps for the condenser circulating water, and when cooling towers are used these pumps absorb a considerable percentage of the current generated. For example, a 15,000-kw. set (maximum rating 18,000 kw.) with condensers and cooling towers, using, say, 17 lb. of steam per kilowatt-hour, requires 1,700,000 gal. of circulating water per hour to be raised to the top of the cooling towers. As all this energy is wasted, the price of the units actually sold has to cover the cost of the units used in this way. This does not, however, complete the account, as in some cases large fans are used to blow away the heat from the cooling towers. In one station for a plant of the above size I have seen 24 fans, absorbing 540 hp., used for this purpose, thus further reducing the salable units.

Water lost in vapor is another expense which has to be met. In the station referred to above, the water required to make up the loss for the 15,000-kw. set is 720,000 gal. per day of 20 working hours.

Assuming that cooling towers are in daily operation for generating sets of, say, 1 million kw. in the same ratio, the water required to make up the loss would be 14,600 million gal. a year.

These figures and facts being assumed correct, the question is: Can anything be done to lessen the waste, or in what way can the heat be utilized? This is a difficult problem, but its complexity should not prevent an attempt being made to deal with it as far as possible.

To find a market for the heat is the first main difficulty and, if this is obtained, the further difficulty arises of co-ordinating the loads. Heat for warming houses, institutions and public buildings is required for only 6 to 7 months of the year, and with our moderate and variable climate the heat load would vary tremendously. There is, however, a constant demand for hot water throughout the year, the quantity depending upon the type of buildings in any locality. The possibility of utilizing the heat depends very largely upon the position of the electric generating station in relation to that of other buildings requiring heat or hot water, on account of the difficulty and cost of transmitting the heat to any great distance. Some electrical engineers, therefore, advocate the use of electric current for all heating and domestic purposes.

Everyone is bound to admit the convenience of an electric supply for heating, cooking, etc., its cleanliness and adaptability, also that the losses in transmission are

less, and that many difficulties inseparable from the laying of large steam or water mains would be eliminated, but at what a cost. The consumer wants heat and, in order to supply it, the average electrical undertaking buys coal, throws away about 95 per cent of its heat, and transforms only about 5 per cent into electrical energy. This means that for every electrical unit (equivalent to 3411 B.t.u.) about 5 lb. of coal at 14,000 B.t.u. per lb., or a total of 70,000 B.t.u. has to be consumed. The cost of running auxiliary plant at the generating station, and losses in distribution still further reduce this small percentage. With present methods,

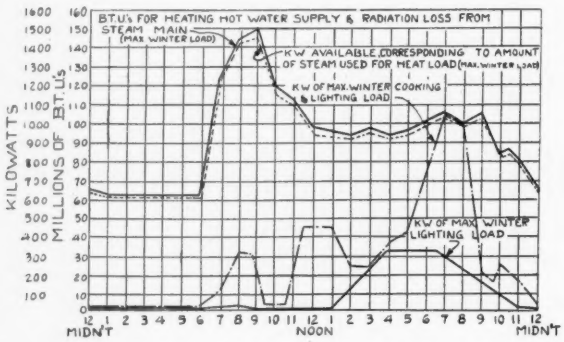

B.T.U's FOR HEATING HOT WATER SUPPLY & RADIATION LOSS FROM STEAM MAIN (MAX. WINTER LOAD)
KW AVAILABLE CORRESPONDING TO AMOUNT OF STEAM USED FOR HEAT LOAD (MAX. WINTER LOAD)
KW OF MAX. WINTER COOKING & LIGHTING LOAD
KW OF MAX. WINTER LIGHTING LOAD
KILOWATTS
MILLIONS OF B.T.U's
MIDNT
NOON
MIDNT

FIG. 1. AVERAGE WINTER LOAD CURVES FOR COMBINED CENTRAL HEATING AND POWER PLANT

therefore, it is a most wasteful form of heating and quite impossible if coal is to be conserved.

In the light of the foregoing figures, is it possible to provide a more economical type of plant so as to obtain a higher coal efficiency?

Combination of heat distribution with the generation of electric current will give a higher heat efficiency than any plant already named. It will be noticed that I place heat distribution first, the reason being that the heat load is the deciding factor in the proposition for economy.

Approximately, the quantity of coal consumed for domestic purposes in Britain is 35 million tons a year. As no separate figures are available it can only be assumed that of this amount 10 per cent, or 3½ million tons, are used for central heating and hot-water supply plants. If the coal were used in the most economical type of heating apparatus an efficiency approximating to 80 per cent might be obtained. If that total tonnage had to be used it would be possible to provide steam boilers and electric generators, the electric current being regarded as a by-product. Allowing 8 lb. of steam per lb. of coal, and 115 lb. of steam per kilowatt-hour, with a back pressure of 60 lb. per sq. in., 155 kw.-hr. would be obtained for every ton of coal.

With plant arranged on these lines about 3 per cent (only) of the heat in the fuel would be transformed into electrical energy, that is, about 3 per cent of the coal consumption should be utilized for electricity generation, and the total consumption should be increased correspondingly in order to obtain the same heating duty. For every 100 T. now used for heating purposes, 103 T. would be consumed, making the total 3,605,000 T. On the above basis this would produce a total of 15,965 kw.-hr. for every 103 T. of coal consumed.

I am aware that it is not generally possible to place an electric generating station in a central position so that it can be used as a heating station, because a site is usually chosen close to a railway, river or canal, and often on the outskirts of a town or city.

Much has been heard about the advantages to be obtained by dispensing with a large number of existing generating stations and serving these districts from the super-station by high-tension mains. How, therefore, do these proposals affect the question now under consideration?

I believe I am correct in saying that the positions chosen for these super-stations are close to some waterway, as it is considered more necessary to be near water for condensing purposes than to be near a coal mine, and for the obvious reason that the heat can be washed away and cooler water obtained for the condensers. Is this, therefore, an entirely sound and economical proposition? In reply to such a question I would say that no scheme can be considered complete which does not make some provision for the utilization of the waste heat.

If the super-station is built in a district where there is no possible use for the heat, then the conclusion is that the position is not rightly chosen unless the electrical load exceeds the possible heat load in the district to be served. The area which can be served electrically from one of these proposed stations is, of course, vastly

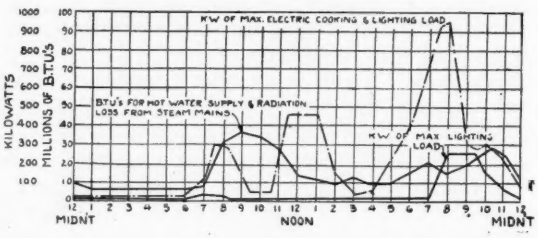


FIG. 2. PROBABLE SUMMER LOAD ON COMBINED HEATING AND POWER PLANT

greater than is possible for the distribution of heat, but the scheme involves the scrapping of many of the existing generating stations within the areas, which seems a most calamitous proposition. A possible alternative is to retain such of the existing stations that can be usefully employed as heat distributing stations, utilize them to their full capacity, and, if there is a greater demand for heat, then provide additional heat stations, using them also for generating electric current as a by-product.

Having completed a careful estimate of the heat load (and of course every plant might be made capable of extension) then by linking up these stations with the super-generating station the balance of the electrical load would be made up at the super-station. This arrangement makes it possible to provide for the varying heat load, and to bring into commission a larger proportion of the plant at the super-station during the summer, when the minimum heat load would occur.

If the lighting load of an existing station is larger than the power load, this lighting load will be found to coincide more closely with the heat load.

I understand that the super-generating stations have been designed upon a comprehensive or national basis, and I claim that it is equally important to consider the

supply of heat upon a large scale. In many manufacturing localities the power load far exceeds the lighting load, but even in such cases many industries require heat in some form for boiling or drying purposes, apart from the heating of the factories.

Special arrangements would have to be made in such instances to supply the steam at a suitable pressure, and this service could be maintained by live steam for continuous processes when the power plant was not running.

Assuming, then, that there is a demand for the heat in the immediate neighborhood of an existing generating station, the question arises: Can the existing plant be adapted to meet both services? It is, of course, quite clear that the utilization of the exhaust steam, even at a pressure of 2 lb. per sq. in., considerably reduces the electrical output, and would therefore involve putting into commission an additional unit or units, thereby increasing the actual consumption of fuel and adding to the total cost of production to maintain the electrical load and at the same time to supply the steam for heating purposes.

Against this added cost the income from the sale of heat would have to be set, and the revenue thus derived would also have to cover a reasonable return upon the capital outlay required for the distributing mains and ducts. This cost would vary according to the particular locality, and the length of main necessary to include suitable buildings. The steam pressure also might have to be varied to meet special local conditions.

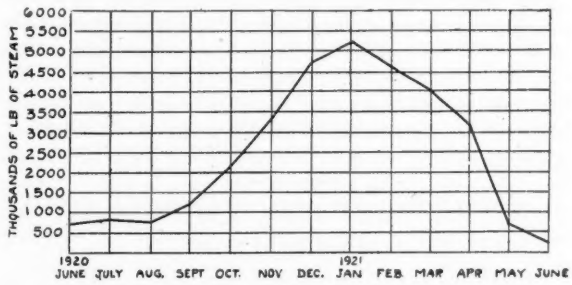


FIG. 3. VARIATION OF DEMAND FOR STEAM DURING THE YEAR

As I fully realize that no electrical engineer would welcome any suggestion which would so materially affect the electrical output of any unit and throw out of commission expensive condensing plant expressly designed to increase that output, I have already alluded to the difficulty of the adaptation of existing plant to meet both services.

If the super-station plan is generally adopted, it involves the scrapping not only of the generating plant but also of the boiler plant and, I understand, using the existing stations only as sub-stations. If, on the other hand, the station remains as a heat distribution station, with a heat load approximately equal to the capacity of the boiler plant, the electrical output becoming the by-product.

As in all probability the demand for electric current would continually increase, the extra boiler power and specially designed generating units would, if space permitted, be provided or the additional current could be supplied from the super-station. The station would then be constituted as a combined heating and electric supply station, with an income derived from both sources.

Then arises the important question: Is such a scheme a practicable and a paying proposition? From an engineering point of view I say it is possible to provide suitable steam mains for the supply of heat and to extend such supply to a distance of, say, 1 mile from the station. There would, of course, be difficulties, but these could be surmounted.

Income to be derived from the sale of the heat depends upon the price charged for the steam supplied, and this should be calculated not only upon the actual

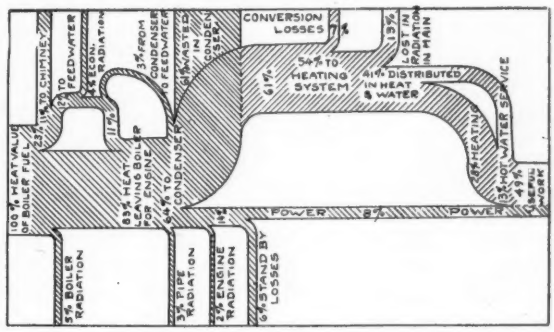


FIG. 4. DIAGRAM SHOWING HOW LOSSES FROM ELECTRIC GENERATING UNITS MAY BE RECOVERED

cost at the station, but also on the cost of its distribution to the consumers, as this would vary according to the distance to which the supply was taken.

Heat supplied would be measured by the amount of condensate, recording meters being fitted with every installation. This would apply in all cases where the condensate could be measured; if steam were supplied for other purposes than heating and hot water supply, it would be necessary to provide steam meters.

From a heating engineer's point of view a central station should be designed to meet the requirements of the immediate neighborhood, whether for industrial or domestic purposes. The three essential services are heat, light and power, and it can safely be assumed that, within ten or more defined districts, not even two would require the same proportion of these services. In a residential neighborhood the heat load would be more constant, and included therewith would be the steam required for hot water supply. The maximum demand for this would occur in the morning, with a lower load in the afternoon and an increased load again during the evening.

This assumed heat load is indicated in Fig. 1 for a complete day of 24 hr. The dotted-line curve gives the approximate rate of electrical output from generators designed to meet the working conditions. The assumed lighting load indicates that at certain hours of the day there is a considerable surplus of electrical energy which is available for other purposes.

If a further demand of current for cooking purposes were added to the lighting load, it would probably show peak periods from, say, 8 a. m. to 8:45 a. m., and 11:30 a. m. to 1:30 p. m., and a further peak from, say, 6 p. m. to 8 p. m. The lighting plus cooking load is also shown, and it will be noted that the possible electrical output

from the heating and hot water service loads covers the demand for lighting and cooking. This diagram (Fig. 1) shows an average winter load. If power is required in addition to the various services above the margin already referred to, it would be necessary to commission other generators to meet this demand, or to obtain the extra supply of current from the super-station.

It is necessary also to consider the requirements of the same district during the summer months. Figure 2 also shows an assumed summer demand for hot water supply, lighting and cooking, and here it will be seen that the omission of the heating load makes a great difference, and proportionately also the electrical output is much less, so that, although the lighting load is so small, when the cooking demand is added thereto the peak periods are above the line of electrical output from the hot water supply. In other words, if electric cooking were used to the extent shown in the figures, there would be three periods per day when all the exhaust steam could not be utilized. It might be possible to provide some form of thermal storage to use the exhaust for these periods, if there were a large local demand for hot water.

Further, when the power load is added (and it must be assumed that such a load would be practically constant throughout the year) it shows the necessity of providing some condensing plant to deal economically with the extra electrical load, or to depend upon the power station or super-station for this supply. If no supply from a super-station were available, then, to meet all demands within the district, the plant would have to be designed with the proportion of condensers necessary for the load variation.

Some generating stations in London and in many cities and towns in the United Kingdom are extremely well situated for heat distribution, and I understand that under the scheme of the super-generating stations many of these would be shut down and the whole of the boiler and generating plant scrapped. It may be argued that the present plant in many instances is obsolete and uneconomical, and purely for the purpose of generating electric current this is doubtless true, but I claim that a large number of these stations with their existing boiler plant would serve excellently as heating stations, thus utilizing the boilers to the best advantage, in which case either a part of the generating plant could be altered to exhaust at a pressure up to 60 lb. per sq. in., or new plant could be specially designed to meet these conditions. I am aware that this involves the retention of a competent electrical staff at these stations, but surely this is justified if the income from the sale of the heat makes the combined station a profitable undertaking.

In some cases, especially in London, the difficulty of fuel delivery is given as a further reason for shutting down, but coal has to be delivered to every house or block of buildings in the district, and the need for this coal would be largely eliminated if a complete system were installed.

As these stations exist with their chimney shafts, no objection could be raised to their remaining, whereas if new heating stations were suggested in some similar positions, considerable opposition would have to be met. In my opinion, therefore, the advantages of retaining the existing stations where they are conveniently situated outweigh all the objections.

Strength of Welded Pressure Vessels

ONE OF THE many difficult problems with which the Boiler Code Committee of the American Society of Mechanical Engineers was concerned in its effort to draw up satisfactory codes governing the construction of unfired pressure vessels was that of welding, according to a communication from the Division of Engineering of the National Research Council. Rules applicable to riveted constructions do not always apply to fabrication by welding.

Because of the meagreness of scientific data upon which to base proper requirements for safety without placing unjust restrictions on the use of welding, the problem is seriously complicated. Wide differences of opinion prevailed not only among the members of the Committee, the insurance companies and inspectors, but also in the industry itself.

For determining whether a vessel was safe for the purpose designed, a hydrostatic and hammer test was finally proposed. The American Bureau of Welding, which is the advisory committee on welding research for the American Welding Society and the National Research Council, organized a Pressure Vessel Committee to co-operate with the Boiler Code Committee in determining the adequacy of the test proposed. Eight manufacturers placed at the disposal of the committee some forty tanks and enough funds. These tanks have been tested to destruction by the U. S. Bureau of Standards.

Shells of most of the tanks were 6 ft. long and 2 ft. in diameter, and made of ⅜-in. mild steel plate. Both electric and oxy-acetylene welding were used. The hydrostatic and hammer test developed that the welded pressure vessel, according to the regular formulas for working pressure has a factor of safety of about 6.

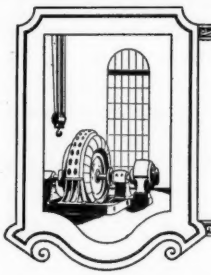
Voice Communication Over 66,000-V Power Line

ANOTHER DEMONSTRATION of the practicability of using carrier current communication over high tension power lines was recently given by the engineers of the Westinghouse Electric and Mfg. Co. and the Duquesne Light Co. These tests carried out between experimental stations located in the Colfax and Brunots Island power stations of the Duquesne Light Co., demonstrated conclusively that voice conversations could be carried on by means of radio waves over power lines without the use of switches and just as is done in ordinary telephone conversations. It was also shown that this system could be used for remote control of all manner of apparatus.

In carrier current telephony the whole idea is to superimpose radio waves on the power lines and thus make use of radio transmitting and receiving for both voice communication and control of remote switches.

These tests conducted Jan. 11, over a 66,000-v. line, were unique in that the telephone system used was duplex and operated the same as the ordinary telephone. In this system, as soon as the telephone is unhooked, the transmitting station automatically starts up, allowing communication in both directions without switching.

All calling or ringing of numbers is selective and operated by special selector keys which cause the bell to ring only at the station desired. This eliminates the distractive code ringing and allows station operators to keep their minds on their work.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Practical Design of Short Transmission Lines

PRELIMINARY CONSIDERATIONS REGARDING TRANSMISSION CIRCUITS IN GENERAL AND FUNDAMENTALS OF D. C. LINES. BY E. K. McDOWELL*

TRANSMISSION LINE theory, even when considered from its simplest aspects, is rather an involved branch of electrical engineering and to the engineer who has not had the benefit of specialized training and experience in electrical engineering, the design of a short transmission line is looked upon as a difficult proposition. Most of the matter available on this subject is either too extensive and bulky for convenient use, or else is arranged in such a form that those without special electrical training have difficulty in picking out the essentials and getting them in logical sequence. Alternating current transmission theory is particularly elusive and the available data is scattered throughout electrical literature in such a manner as to bewilder the engineer who is occasionally confronted with the problem of calculating transmission circuits.

In a series of articles, of which this is the first, an effort has been made, therefore, to present sufficient data in a logical sequence to serve as a basis for the intelligent design of short electrical power circuits, such as may be encountered in many large industrial plants. Since the fundamentals of direct current theory are, as a rule, fairly well understood, the greater part of these articles will be devoted to alternating current circuits, and direct current theory will be treated only to the extent of developing the equations necessary to figure line resistance drop and one or two other matters.

CONSIDERATIONS REGARDING TRANSMISSION CIRCUITS IN GENERAL

IN THE design of circuits, both alternating and direct current, the calculations and theoretical considerations have to do mainly with the problem of determining the most suitable size of conductors. In the case of direct current circuits, this is a fairly simple matter; but the procedure for alternating current circuits is not so simple because additional and important characteristics peculiar to these circuits have to be considered. A knowledge of the general principles of alternating current circuits is, however, necessary in order to recognize the conditions under which various methods will give accurate results.

For either direct or alternating current circuits, there are, in general, three main considerations regarding the size of the conductors. These are as follows:

1. Loss of voltage—must not be excessive.
2. Heating—must be limited to temperatures that will not injure the insulation or start fire.
3. Power loss or energy absorbed in transmitting the current against the resistance of the circuit—must not be excessive.

The problem of design thus becomes the determination of a size of wire that will carry a certain current a given distance without too great a loss in voltage and without absorbing too much energy or becoming overheated. The successive operations involved, while differing in details between alternating and direct current circuits, follow the same typical sequence, which is outlined as follows:

(a) Determine the circuit current in amperes.

(b) Determine the length of the circuit (along conductors) or the distance to the approximate "load center" if the load is not concentrated at one end.

(c) Decide what voltage drop is allowable.

(d) From the proper equations or formulas calculate the size of wire such that the voltage drop of (c) will not be exceeded.

(e) Check wire-size for energy-loss, or energy dissipated in overcoming line resistance, which should be within reasonable limits.

TABLE I. CURRENT-CARRYING CAPACITY OF INSULATED AND LEAD-COVERED CABLES AND COPPER CONDUCTORS

SIZE		NAT'L ELECT. CODE		LEAD-COV'D CABLES		BARE COPPER CONDUCTORS
A.W. gauge	cir. mils	Rubber (amps)**	Weather-proof or slow-burning (amps)**	Single-cond'r paper-insul. (Std.U'gd Cable Co) (amps)		in still air @ 25° C 40° C rise (amps)
8	16,509	35	50	68	These values	
6	26,251	50	70	95	are for 110-	solid
4	41,742	70	90	124	220 V. and	207
3	52,634	80	100	143	for 4-cables	245
2	66,373	90	125	163	per duct	295
1	83,694	100	150	187	bank.	348
0	105,593	125	200	215		416
						stranded
00	133,100	150	225	245		495 527
000	167,805	175	275	283		589 625
0000	211,600	225	325	324		728 750
	250,000	240	350	358		stranded 840
	300,000	275	400	398		970
	350,000	300	450	437		
	400,000	325	500	472		
	500,000	400	600	538		
	600,000	450	680	608		
	700,000	500	760	660		
	750,000	525	800	685		
	800,000	550	840	715		
	900,000	600	920	767		
	1,000,000	650	1,000	817		
	2,000,000	1,080	1,670	1,320		

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** for aluminum wire use 84% of these values.

DIRECT CURRENT CIRCUITS

IN MANY instances the load which is to be supplied with energy by the contemplated circuit will consist

*Chief Engineer, Donora Steel Works, American Steel and Wire Co.

of one or two units or groups of units, and the total kilowatts will be fairly definitely known. In other cases where mixed loads of considerable magnitude are encountered, it may be necessary to give consideration to the diversity element of the load; also, in many cases, it is advisable to make a reasonable addition to the actual net kilowatt demand to provide for future growth.

Assuming the load to be known, the line current can be readily determined provided that the voltage (at which energy is supplied to the load) is known. This should preferably be taken as the sending-end voltage (voltage of generators) less whatever voltage drop it is decided to assume as allowable.

Then since (by definition of one watt) $P = EI$,

$KW = EI \div 1000$, whence

$$I = (KW \times 1000) \div E \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where I = current in amp.; E = line voltage; P = power in watts; KW = power in kilowatts.

The line current is thus determined by equation I.

For motor circuits, the allowable voltage drop should not, generally speaking, exceed 10 per cent, and from an operating point of view, it is better to limit it to 5 per cent. In a motor or mixed load circuit with several branches, the total allowable drop may be arbitrarily apportioned; say, 1 v. in individual branches, ⅔ of the remaining drop in the feeders and ⅓ in the mains supplying the feeders. Branch feeders to individual motors should always be figured on basis of full load current to the motor.

Size of Wire to Give the Allowable Voltage Drop

This can be most conveniently calculated by the use of Ohm's law so modified that the resistance R is expressed in terms of length in conductor, circular mils of cross-sectional area, and the unit resistance per circular mil foot of copper wire. Taking the latter unit as 11 ohms per circular mil foot, which is a sufficiently accurate asumption and easily remembered, the following equation results:

$$\text{cir. mils} = (22\ IL) \div E_1 \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where the symbols used are as follows: I = circuit current in amps.; L = one-way length of circuit in ft.; E_1 = drop in voltage in the circuit. The size conductor that will give the allowable voltage drop can now be chosen, selecting the nearest commercial size having an area in circular mils not less than that given by equation 2 (see Table I, page 229).

Current-Carrying Capacity

While a conductor or circuit may have ample cross sectional area to carry a given current a given distance without exceeding a maximum specified voltage drop, yet it may be so small that it will overheat. Table I shows, for the sizes of wires and cable usually employed, the maximum current that each size will carry without overheating. This table should be consulted and the conductor size increased if necessary. Cables with weatherproof covering are shown in the table as having higher current-carrying capacities than those with rubber covering; since the former can be operated at higher temperatures without danger of impairing the insulation.

Underground cables in duct lines are generally lead covered and may be either paper, cambric, or rubber-insulated. The heating limitations for this class of cables depend upon several conditions; such as the voltage, number of conductors per cable, number of cables per duct bank, etc. The table gives current carrying capacities per conductor for low voltage (100-220) single-conductor paper-insulated lead-covered cables; values being based on an allowable temperature rise of 65 deg. C. above an assumed normal ground temperature of 20 deg. C (68 deg. F.)

For a two-conductor cable, the allowable current can be taken as 90 per cent, and for a three-conductor cable 75 per cent of the table values in amperes per conductor. For voltages higher than those specified above, multiply the table values by the following factors for the respective working voltages (in kilovolts). (These values apply for a four-duct bank, or system; for more ducts in the bank a reduction of the table values has to be made on account of heating effect of the other cables, etc., for which factors will be given in a later article.)

Working voltage in kilovolts..	5	10	15	20	25
Factor	.96	.92	.88	.83	.78

These table values for current-carrying capacity of lead-covered cables, together with the above factors, were furnished by the Standard Underground Cable Co., and are published here by special permission of that company.*

Motor Branch Circuits

Motor branch circuits are required by the National Electric Code rules to be of sufficient size safely to carry a current 25 per cent greater than that required by the motor. While in many cases compliance with these N. E. Code rules may not be obligatory, it is nevertheless good practice to follow this particular rule for all branches to individual motors wherever located. The use of any wire smaller than No. 14 is prohibited by the N. E. Code and should be avoided. For outdoor service no copper wire smaller than No. 8 or 6 has sufficient mechanical strength to give satisfactory service.

Energy Loss

Energy loss or power dissipated in overcoming line resistance should finally be figured. This should, generally speaking, be kept down to 5 or 10 per cent, since usual practice is to design transmission systems as about 90 per cent efficient. A conductor that satisfies the current carrying capacity limitation will not generally show a power loss in excess of these figures. The power loss in any given conductor is computed as follows:

Since $P_1 = E, I$, and $E_1 = IR$, we obtain (by eliminating E_1) $P_1 = I^2R$ (a)

where P_1 = watts lost in overcoming line resistance

R (ohms)

I = line current (in amps.).

Also if l = tot. length of conductor

L = one-way length of circuit (= l ÷ 2)

it can be shown that

$$R = \frac{11 \times l}{\text{cir. mils}},$$ which can be written

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$$R = \frac{22\,L}{\text{cir. mils}} \qquad (b)$$

whence, combining (a) and (b), to eliminate R, we have

$$P_1 = \frac{22\,I^2L}{\text{cir. mils}} \qquad (3)$$

This equation (3) applies alike to direct and alternating-current circuits; since, as will be shown in subsequent articles, there is no power lost in the latter from inductance or permittance.

Largest Power Cable in World Laid in San Francisco Bay

AMONG THE recent engineering achievements on the West coast, one of the most noteworthy was the laying of the longest and highest capacity power cable in the world under San Francisco Bay by the Great Western Power Co. This cable, which stretches from Pier 41, San Francisco, to the shore of Richmond, a distance of 8 mi., is the fourth of the company's trans-bay cables laid since the first in 1911, which pioneered the way in submarine power transmission.

As may be expected, the feat brought coastwise interest from electrical men, especially since an additional 15,500 hp. will be brought into San Francisco

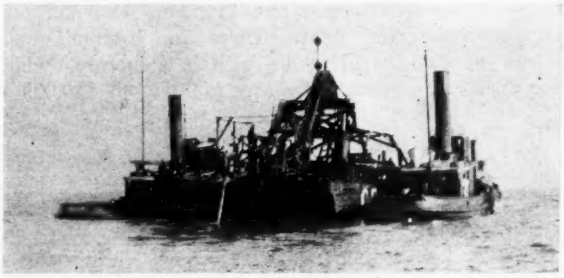


FIG. 1. SHOWING CABLE BEING FED INTO BAY. NOTICE 12-FT. DRUM OVER WHICH CABLE PASSES AND THE CHUTE LEADING TO STERN

from the new Caribou Power Plant 200 mi. away with a minimum of expense in crossing the harbor.

This is the longest high voltage cable that has ever been manufactured, according to A. O. Hoeftmann, cable engineer for the American Steel and Wire Co. at Worcester, Mass. The 15,500 hp. will be sent under the bay at 11,000 v.

With the laying of this fourth cable, a total of 35,500 hp. of hydroelectric energy is now brought into San Francisco, the first three cables laid, having a combined capacity of 20,000 hp. An additional 35,000 hp. is generated in San Francisco by the company's two steam plants.

At the Caribou power plant the first two units are now in operation, generating 60,000 hp. The current at 165,000 v. is transmitted to the new Golden Gate substation at Richmond (a distance of 200 mi. over the steel tower transmission line) where current is reduced to 11,000 v. for distribution. This substation has just been completed at a cost of $2,000,000.

Several important engineering problems were solved in the present undertaking. One was the transmission of this great amount of power under the water without leakage, and another, the splicing of the cable ashore, the splicing being reinforced with a steel sleeve.

It required nine steel freight cars to transport the cable, in as many lengths, from the factory of the American Steel and Wire Co. at Worcester, Mass. Special mechanics were brought to the West coast to attend to the splicing. The whole cable, weighing 500 T., was then coiled on a barge (towed by three tug boats), and dropped over a chute into the water. A dozen workmen guarded the unwinding of the cable to prevent kinking. Eight brakes, wooden shoes attached to levers, checked its progress over the stern. The cable was laid in 3 hr.

Although the cable is 8 mi. in length, it is laid over a distance of only 7 mi. in order to give one mile of

FIG. 2. AT RIGHT CAN BE SEEN THE CHUTE LEADING TO THE STERN OF THE BARGE

slack. This makes it possible to pick up the cable without trouble and bring it to the surface at any time for any necessary repairs. The cable is 4 in. thick. Within its armor of heavy wire are three power cables, packed in jute, and three pairs of telephone wires. Each power cable is composed of a large number of separate insulated copper wires. The cable weighs 20 lb. to the foot.

The present cable laid at a total cost, including freight, labor and insurance of about $200,000, will take the place of wiring around the southern end of the bay that would cost, it is estimated, at least $1,000,000.

Anchorage is forbidden by the California State Harbor Board along the course of the power cables.

High Temperature Solder for Carbon Brushes

By J. D. Alley

ORDINARY solder is made up of tin and lead in different proportions, these proportions being varied according to the melting point desired. During the war tin became scarce, and the price advanced until it became almost a necessity to find some substitute for tin in solders, both from the standpoint of economy and because all available tin was urgently needed for other uses. Among other research organizations, the

Westinghouse Research Laboratory worked on this problem, and from many mixes of different metals in different proportions two alloys were developed by Dr. C. W. Hill which could be used as successfully, under certain circumstances, as ordinary solder, and promised better results where a higher melting point was desired. No particular application, however, was made of these solders.

Solder at present used to fasten shunts to carbons is tin 50 per cent, lead 50 per cent, commonly called half and half. This solder has a melting point of 180 to 188 deg. C., but periodically it has caused trouble by melting and running out when the carbons heated under severe working conditions. The two high melting point solders are lead 91.5 per cent, cadmium 8.5 per cent, nickel 2 per cent, melting point 401 to 402 deg. C. Either of these, on account of its much higher melting point, would eliminate the trouble occurring with the half and half, so a further comparison of the two was made by soldering copper strips together with lap joints and submitting to three tests. 1—A wet rag was wrapped around the soldered joint and kept moist. 2—The copper strips were suspended in a ten per cent solution of aluminum chloride. 3—The copper strips were put in an oven held at 200 deg. C. The half and half would have failed at a lower temperature than this.

Three fluxes were used in this comparison: 1—zinc chloride-hydrochloridic acid solution; 2—compound chloride flux composed of sodium chloride 11 per cent, potassium chloride 14 per cent, zinc chloride 65 per cent and ammonium chloride 10 per cent; 3—Westinghouse non-corrosive soldering paste, essentially a zinc resinate paste. The lead-cadmium solder proved much the better of the two, as all joints soldered by it were still sound when the joints soldered by the zinc-nickel had failed.

Lead-cadmium solder cannot be used as a pot solder because it oxidizes so readily, and since it is necessary to heat it almost 100 deg. higher than half and half, the control of the temperature in the soldering pots would be difficult. Since the half and half solder was, however, used in pots and the carbons and shunts were tinned by dipping, efforts were made to use the lead-cadmium as a pot solder by using a protective coat to prevent oxidation. A number of different substances were used, but with indifferent success, as the solder would not wet the copper plating on the carbons after dipping through the protective coat.

Westinghouse non-corrosive soldering paste was used in all our work with carbon brushes. We tried mixing the solder in the form of very fine filings with the paste and soldering by heating the brushes to the required temperature with a layer of this solder paste between the shunt and carbon. Good joints were obtained in this way, but often when pulled and examined we found that the solder did not make a solid joint, probably on account of its not being in a fine enough state of division.

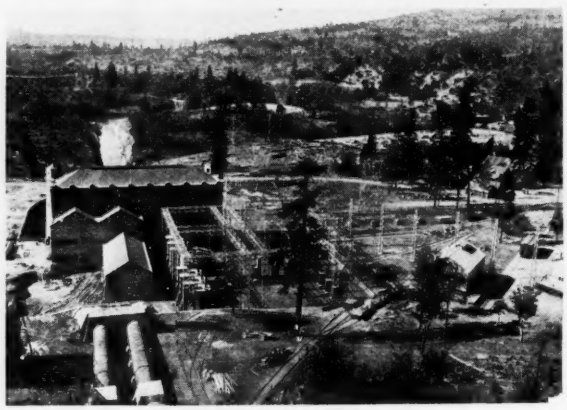
It was finally decided to melt the lead, add the cadmium and cast it in the form of thin flat slabs. These were then rolled to thin sheets varying from 0.001 to 0.025 in. in thickness. Ordinarily sheets were used varying from 0.005 in. to 0.015 in. according to the size and style of brush. The sheet of solder was placed between the shunt and carbon with a little flux, heated to the required temperature, clamped and cooled quickly with a blast of air.

Joints made in this way were given a rough test by pulling by hand and in all cases either the copper stripped from the carbon or the carbon broke. This method of sheet soldering eliminates another trouble that frequently occurs when the soldering is done by half and half; i. e., when the shunts are dipped for tinning, the solder runs up the leads and causes them to break under vibration when in service. A vibration machine was set up in which the brushes soldered with lead-cadmium solder and protected by metal shoes to prevent undue wear of the carbon, were held in clamps against the rounded teeth of a rapidly revolving wheel, thus being subjected to a rapid and severe vibration. There were no cases of breakdown of the soldered joint during a test lasting several months.

Lead-cadmium solder can be used to solder by hand, but requires preheating of the objects to be soldered. It is being used at present to solder the leads on rectigon bulbs, and is giving much better service than lead 75 per cent, tin 25 per cent or pure tin. On account of its high melting point and mechanical strength it should find other uses besides the one mentioned above, and its use on carbon brushes.—Electric Journal.

Transformer Handling House Is Part of Power Plant

IN THE construction of the Pit River Power Plant No. 1 the transformer handling house was built as part of the power plant. There are 7 transformers placed outdoors under the switch structure, which transforms the current from 127,000 v. to 220,000 v.



VIEW OF PIT RIVER PLANT NO. 1 SHOWING 80-T. TRANSFORMERS

A track parallels these transformers and a special steel truck has been provided for transporting these transformers (each weighing 80 T.) from the outside to the transformer handling house and back again.

In the accompanying illustration these seven transformers may be seen at the left of the switch structure. The transformers were each taken into the house, the cores removed, the tank inspected, assembled and dried by compressed air. For this purpose there is a portable apparatus consisting of an air compressor and grids for heating the compressed air. This heated air was blown through the coils and they were dried out in three weeks. The Pacific Gas and Electric Co. has about 20 such portable outfits throughout its system.

Health Problems in Industry---II

INDUSTRIAL DUST AND ITS DANGERS; CONTROL OF INDUSTRIAL POISON HAZARDS, SANITATION IN THE FACTORY. BY DR. C.-E. A. WINSLOW

ASIDE FROM the general problems of ventilation, which are essentially the same in the workshop or in the power plant, the manager has often to deal with atmospheric conditions of a special type resulting from the conduct of the actual processes of industry. Among the most serious of such conditions are those which result from the presence of certain varieties of dust.

Among the industrial dusts there are many different kinds, some of no sanitary significance and others which constitute a very real danger to the health of the worker. Many of the common organic dusts such as those which are present in carpenter shops, flour mills and textile mills seem to have very little influence upon health. Other dusts, such as those generated in processes involving the use of lead compounds, may be poisonous.

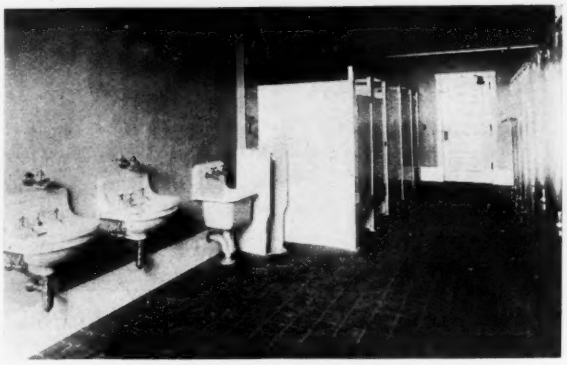


FIG. 1. A GOOD EXAMPLE OF A WELL ARRANGED TOILET ROOM IN A POWER PLANT

A third class of dusts, including chiefly those of a metallic or mineral nature, constitutes a serious menace by injuring the lung tissue and predisposing to tuberculosis.

It is probable that all hard inorganic dusts and certain organic dusts produce a more or less definite irritation of the lungs and the upper respiratory tract and the inhalation of any such dusts causes an increased tendency to diseases like pneumonia and bronchitis. With regard to tuberculosis, however, there are curious differences between the effects of individual dusts. Cement dust and coal dust, for example, are not associated with an undue amount of tuberculosis but rather the reverse. Coal miners show a tuberculosis rate distinctly below the average. On the other hand, quartz dust and metallic dusts, such as those to which tin miners, lead miners, granite and marble workers, sandblasters, grinders and polishers and pottery workers are exposed, do lead to an excess of tuberculosis so marked as to constitute an industrial problem of the gravest significance. In a study conducted under the direction of the author it was found that the grinders and polishers in a certain axe factory had a death-rate from tuberculosis over ten times as high as that of the other employes of the same factory.

This problem of atmospheric dust is one which cannot easily be solved without expert assistance since it is not at all possible to estimate the danger involved merely by the appearance of the air of the workroom. It is the small particles of dust which are harmful and they may be present in dangerous amount in what looks like a clear atmosphere. Any industry which carries on grinding and polishing or metallic dust should, if possible, have the dust content of the air determined by an analyst in order to see whether a safe limit is being exceeded.

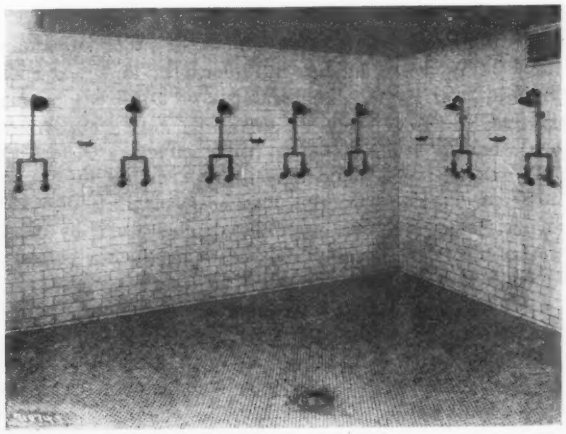


FIG. 2. GENERAL SHOWER AT THE PLANT OF INDIANAPOLIS DROP FORGE CO.

Where atmospheric dust is present to a dangerous extent, there are several practical methods of control adapted to the various processes concerned.

In certain instances it is possible to eliminate atmospheric dust more or less completely by substituting a wet process of treatment for a dry one. Thus white lead is now ground under oil instead of in the old dry fashion; and one of the greatest poisonous dust hazards, that of rubbing down paint, can be accomplished by the use of wet process with special waterproof sandpaper. Wet grinding wheels, other things being equal, produce much less dust than dry wheels. It is important, however, to note the qualifying phrase and to remember that wet processes of grinding may produce dangerous amounts of atmospheric dust. In fact, the enormous tuberculosis death rate in the axe factory to which reference has been made above, was directly due to the dust discharged from wet wheels of natural sandstone.

In other cases, the dust hazard may be controlled by carrying out dusty work in enclosed chambers fitted with exhaust ventilation. Various sifting and grinding and tumbling processes and the sandblasting of small objects are accomplished in this way and if the apparatus is properly constructed the results may be wholly satisfactory.

Dusty processes which must be carried out in the open can often be rendered safe, on the same principle,

by the provision of hoods and exhaust ducts to carry off the dust from the point at which it is generated.

Finally, in processes like the standblasting of large castings none of the procedures discussed above will serve. Here the workers must necessarily be surrounded by clouds of dangerous dust and can only be effectively protected by wearing an appropriate helmet and respirator. If the helmet be connected with an air pressure line maintaining a slight positive air pressure so that there is a constant outflow through its wire mesh, an entirely adequate protection may be secured.

Control of Industrial Poison Hazards

Industrial processes in which poisonous substances must be used are almost innumerable; and text-books on industrial hygiene contain lists of hundreds of such poisons. Some of them are used only rarely and a very few workers are exposed to their effects. Others are only slightly poisonous, causing, perhaps, no discomfort more serious than a temporary irritation of the skin. Some, on the other hand, are used by many workers and are so poisonous as to produce a considerable number of deaths every year.

Of all the industrial poisons, the compounds of lead are by far the most important. Metallic lead itself is not toxic, but the fumes which form when it is melted are poisonous and the various lead salts, such as the carbonate (while lead), the acetate (sugar of lead), the various oxides (red lead, litharge), are extensively toxic. Lead smelting, white lead making, the manufacture of storage batteries, the manufacture of pottery and sanitary ware and above all painting (with red and white lead paints) are perhaps the most dangerous of the lead processes.

Lead poisoning is effected either by the breathing of an atmosphere laden with lead dusts or by getting lead compounds into the mouth from the fingers or in other ways. As a rule, the inhalation of dust is by far the most important factor. First and foremost then, the worker who uses lead salts or other poisonous compounds, should be protected by all possible devices for controlling dust. Dusty processes should be carried on whenever possible in enclosed spaces or under water or oil. Hoods and exhaust drafts for the removal of dusts and fumes should be installed; and where all other methods fail the workers must be protected by effective masks, respirators or helmets.

In addition to such measures for the control of atmospheric dust, it is almost equally important to provide for such measures of cleanliness as will reduce the danger of transferring the poisons directly to the mouth. Impervious and well-cleaned floors and work tables, the prohibition of eating in the work room (with the provision of a clean and convenient lunch room), special working clothes with separate lockers for home and work clothes, hot water, soap and nail brushes with allowance for washing up *on company time*—these are among the chief conditions which will reduce the danger of the poison hazard to a minimum.

Finally, the workers in lead should without exception be subjected to a full physical examination at regular intervals (ideally once a month) for the detection of early signs of poisoning which indicate the necessity for an immediate change to some other job where the lead hazard is not involved.

It is impossible in a brief article even to list all the industrial poisons; but mention may be made of the mercury salts which cause "Hatter's shakes" in the felt hat industry, of arsenic salts which cause serious skin irritations among workers with Paris Green, of the fumes from unmolten brass which cause "brass-founder's ague," of the fumes of nitric and hydrochloric acid which irritate the membranes of nose and throat, of carbon monoxide, of wood alcohol, naphtha and benzine, and of the various poisonous substances used in the munition industries. The general methods of control are much the same in most cases as those discussed above, the removal of dusts and fumes and the periodic medical examination of the workers being always of primary importance.

Carbon monoxide is given off from ovens, furnaces, and all sorts of heat sources when combustion is incomplete. It is a sudden and acute poison causing throbbing of the temples, nausea, hallucinations and sometimes almost instantaneous death. Its control may to some extent be effected by supervision in regard to leaks but in many industries there will always be danger of "gassing." Where such danger exists workmen should go about in pairs and if on elevated platforms supported in some way so that a loss of consciousness would not involve a fatal fall.

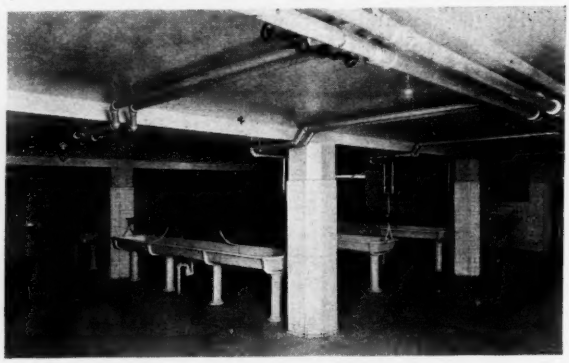


FIG. 3. SECTION OF MEN'S TOILET ROOM, INDIANAPOLIS DROP FORGE CO.

Sanitation in the Factory

Under the preceding headings we have considered certain special problems of industrial hygiene such as those created by the production of poisonous fumes and irritant dusts. There are other precautions against preventable disease of a more general nature which require consideration in the factory, although they are quite as important in the schoolroom or in the home.

Diseases of the communicable type are, of course, due to parasitic germs which grow in the body as a mold grows in jelly and poison it by the chemical toxins which they form. The great majority of bacteria and other germs are entirely harmless. They are found everywhere, in water and soil and particularly in decomposing organic matter and some of them, like those which maintain the fertility of the soil, are highly beneficial to mankind. The relatively few forms which cause disease are specially adapted to live in the rich warm fluids of the human body and cannot survive very long anywhere else. Every case of communicable dis-

ease, such as tuberculosis, typhoid fever, diphtheria, influenza and the common cold, results from the rather direct transfer of the specific germ from one human being to another. If we can prevent this transfer, we shall control communicable diseases.

Since the germs of communicable disease generally leave the bodies of infected persons in the various discharges, it is first of all important to care properly for these discharges. Promiscuous spitting, for an example, is an obvious and important danger, since the sputum of those who appear at the moment to be well may often contain germs of disease to which the person discharging them is resistant, but which are capable of producing severe attacks in others. In factories where expectoration is common, it is therefore essential that an ample supply of cuspidors should be provided, best, perhaps, the cardboard type that can be burned, or wide-mouthed metal cans filled with sawdust. In shops where the employes are of a higher type and where expectoration can be entirely prevented, the cuspidor should be eliminated.

Provision for the proper disposal of bowel wastes is another important point in shop sanitation. In small factories where no water carriage system exists, privies should be placed at a convenient distance and maintained in an absolutely fly-proof condition. Where water closets are installed, they should be located in special compartments with ample light and air. Wherever possible, these toilet compartments should be on the outside of the building so as to provide for the free access of daylight; where inside toilets are used, they must be amply lighted at all times from artificial light sources. A dark toilet room is certain to be a dirty toilet room and a dirty toilet room furnishes the most dangerous opportunities for transmitting the germs of communicable disease from one person to another.

Another point of prime sanitary importance is the water supply of the factory. Its original source must be free from any possibility of sewage contamination. This means that taps connected with a canal water system should never be placed where the operatives may use them for drinking since canal water is reasonably certain to receive the discharge of sewers above. The labeling of taps "Canal Water—Do Not Drink" is *not* a sufficient protection, since such a warning is certain to be ignored by the ignorant. If a city supply is not available, water from a driven well will generally be found most satisfactory, provided it is analyzed three or four times a year at some competent laboratory to make certain that it is free from pollution.

It is now universally recognized that the common drinking cup is an admirable means of spreading disease germs from one mouth to another and should not be tolerated in any well managed factory. Paper drinking cups or bubble fountains should be used. The common drinking cup is of course only one of many means by which disease germs may be spread. The common washing trough is another of almost equal importance and where long troughs are provided for hand washing they should have no outlet plugs so that only running water may be used.

Even when all such specially easy channels of disease transmission have been eliminated, there will always remain certain opportunities for direct contact infection between the persons who congregate in a factory workroom. It is quite impossible to guard entirely against the spread of communicable disease. It will materially aid in reducing such diseases, however, if it is understood by the foreman that it is economical in the end to keep out of the workroom persons who are obviously suffering from some sort of contagious disease which may be spread to others. Coughing, sneezing, running nose and eyes are signs that something is wrong and where a good industrial medical department exists any employe showing such symptoms should be sent promptly off to the nurse or the doctor for examination. What seems merely a light cold in the head may prove to be the beginning of a severe infection, or may give rise in others to a severe infection. In such cases, a few days of absence on the part of one worker may save weeks of lost time on the part of others.

For the photographs accompanying this article we are indebted to Crane Co.

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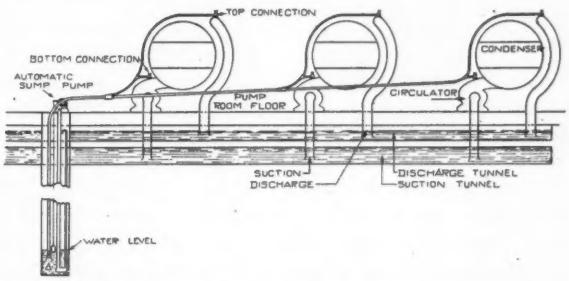
Suggestions for Improvement in Power Plant Design

SOME DETAILS THAT IMPAIR EFFICIENCY. BY JOHN U. MORRIS

IT IS quite probable that in the near future a large portion of the steam central stations will be stand-by power. With the development of the high tension transmission, economically, and the increase in size of steam



CIRCULATOR SYSTEM AIDS STARTING AND ELIMINATES AIR BINDING

prime movers, it is evident that our comparatively small steam units will continue to hold an important place for carrying over the peak loads, and in emergencies, for some time to come.

In view of the fact that the outlook on the power industry is rather promising for the future, and that central station plants have now settled down to pretty well organized systems of standardized routine, it behooves the designers to concentrate more on plant efficiency from the standpoint of practical operation.

LITTLE THINGS REGARDING ROOM TEMPERATURE

TO ILLUSTRATE: We will say a central station is laid out, the best pumps used, the most efficient heat balance worked out, and when water rates are taken, they conform to guarantees, etc. Later, however, after the plant has operated some time, numerous things crop out.

In some particular corner, among the auxiliaries, the room temperature runs very high. The oiler can stand this—yes, quite readily, especially if he is used to it; but at this place the whole condenser, when in operation, is completely covered with moisture. This moisture drops continually on the circulators, or we will say the hot-well pump. The shafts and bright work are all tarnished and finally corroded. That particular part always has the floor covered with water. Valve stems are rusted and require repacking continually and then finally have to be renewed. To sum up the situation, that particular corner becomes the workhouse for the operating force—and a very disagreeable one at that. Instead of keeping the equipment running, polished up and in tiptop shape, they are lucky to keep it going at all. A man is sent there to do a job. He does it about as quickly as he can and the result is a good-for-nothing one, lasting just long enough for the next man to do over. So it goes—that corner (it is a fortunate plant that has only one corner like the aforementioned) is the engineer's nightmare and always will be.

That condenser was of correct design, the pumps were right and everything checked up satisfactorily; but who formed a picture in his mind's eye how that was going to look in full operation? "Looks" count for a great deal in such cases. I have read considerably about Henry Ford's plant, and it is my firm belief that one of the fundamentals that go to make such remarkable efficiency (in his factory too) is cleanliness.

Right and Wrong Places for Auxiliaries

Still another thing about placing of auxiliaries. Pumps invariably are put in the most ridiculous positions (to say nothing of the main engines, sometimes).

Everything might be quite right from the artistic standpoint of a spectator or for a man walking down the main aisle with a 10-ft. plank on his back; but how about the overhauls and necessary work to be done on the all-important things, which are tucked away, here and there, out of sight? I would be quite pleased to show any power plant designer any number of instances where pumps actually have to be moved off their foundations to get at certain parts for overhauling.

When auxiliaries are so placed, men unconsciously steer clear of them, and not only are they taken care of in a slipshod manner, but in many cases the men do not even take the trouble to see where all the connections are and how the machine actually works.

Another Thing Is Piping

Personally I can see no reason why complete piping systems cannot be arranged on a regular separator floor, covered only with removable subway grating. They then would be easily accessible. Corrosion, bad valves and leaking joints would be quickly noticed and corrected. Piping run in sewer trenches and behind tanks is never touched and is in exactly the places where it is most apt to deteriorate.

We will all admit that a beautiful turbine room floor with highly enameled engine looks fine indeed; but why be "four-flushers," and cover the auxiliary room with steel or cement floors, then triple partition it with a confused mass of dirty and leaky pipe?

I-beams, pipe and small machinery do not look so ungainly if they have a substantial coat of paint applied and later glossed with good varnish; besides such a smooth finish is easily kept clean.

Obviating Some Difficulties with Circulating Systems

It has been found to be good practice in stand-by plants to keep a circulator ready in case of unexpected or sudden rise in load when an additional unit is needed in a hurry.

Unless the circulator system is absolutely tight, the water will immediately start to recede as soon as the pump's engine is shut down; and to raise the water again takes time, which is a most important item when the machine must be up to speed in a hurry.

So in view of this fact, a great many plants find it necessary to run the circulator on the reserve machine during such times as it may be called for. But even with this precaution, it is possible that more than one machine is needed right away; in fact, the full capacity of the station may be required.

If such a system were installed, as shown in the accompanying sketch, I think a great deal of worry on the above-mentioned score would be eliminated. The inclined lateral line would be run the length of the pump room, having branch connections to each unit. These lines could be tapped off the highest points on the circulator water boxes and lines. In this way it would not only be possible to remove all the air from the system, but it would also be possible to keep it removed. In regard to the latter feature, I have in mind one case of a circulator, where four or five rows deep of tubes on the top of the condenser had to be removed and the tube sheet plugged on account of air pockets.

It seems that owing to the design of the condenser and its members, air pockets would form in such a way as to keep the water from flowing through the top rows of tubes. In such a condition they, of course, did not last long, and it was found necessary to remove them.

Valves marked in the sketch, as top and bottom connection, would be in the same location as the suction of a steam syphon, which is generally used for removing air from the system. Many installations have a bypass connected from this point to the fresh water side of the condenser. The general method of starting up, in this case, would therefore be to start the air pump, with the bypass open, then shut it as soon as the water is "over." A deep well would be an expensive item, but operating difficulties and resultant inefficiency would compensate this additional expense.

Delays may cause loss, distinct from that occasioned by idle time. They either may or may not be accompanied by this; in fact, they are sometimes desirable or even necessary in one place, to prevent idle time in another. So while they do not cause loss to the employer, in pay for days' workers, or to piece-workers by lessening their earnings, they may interfere with prompt shipment or fulfilment of contracts; and in any case, they are apt to upset the schedule. They also increase the overhead percentage; sometimes the amount, too.

Robert Grimshaw.

Heat Losses Accompany Draft Variation

COMBUSTION CONDITIONS DISTURBED BY EXCESSIVE MOVEMENTS OF DAMPER CONTROLLED BY STEAM PRESSURE. BY JAMES L. KIMBALL

IT IS not practical to attempt to save all the heat units in fuel. There are, however, certain avoidable losses and one of the largest is found in improper draft control. Excess air to the boiler furnace means high stack losses and low boiler absorption, while a deficiency of air means losses due to unburned gases. Best efficiency is reached with the smallest amount of excess air possible without producing unburned gases. Draft regulation may contribute rather than prevent the avoidable losses.

Fluctuations of air supply in excess of the load fluctuations result either in an excess or a deficiency of air. A regulator which fluctuates air supply in excess of the load requirements only momentarily touches the point of best efficiency as the air supply is fluctuated from one extreme to the other. The loss in efficiency due to operating over a wide pressure range consistent with load fluctuation would in the most of cases be small provided the mean average load was at maximum efficiency rating. But the loss due to a continuous fluctuation of air supply in excess of load requirements, or an air supply which is not consistent with the thickness of fuel bed is the chief source of avoidable waste.

Draft regulators that operate in virtue of variations of steam pressure above or below a predetermined normal point aim to secure a maximum sensitiveness to pressure variations, so that the draft is controlled from one extreme to the other on a slight variation of steam pressure. This type of regulator may, therefore, be properly considered as aiming to secure uniformity of steam pressure and disregards disturbance in furnace conditions.

Regulators of the compensating type work on the principle that the air supply should vary between minimum and maximum amounts according to the rate at which steam is being withdrawn from the boilers. As a certain variation in steam pressure is necessary to operate them over their entire range of action, it will be obvious that their purpose is to maintain uniformity of furnace conditions with correspondingly increased fuel economy, rather than to maintain a uniform steam pressure between very close limits.

On the theory that maximum air should be supplied at the load peaks, but not before the peak is reached, the load factor of a plant should be the basis for determining pressure range between operating limits.

It would seem desirable to establish a series of fixed conditions corresponding to definite boiler ratings and supply steps on a compensating attachment determining these fixed positions.

With uniform loads a 5-lb. range with 10 stepped positions with a ½-lb. rest at each step can be used to advantage, but with fluctuating load such a range would approach a dead open and shut proposition, and the range between minimum and maximum fuel and air supply must be increased or the number of steps decreased or both, in order to effect the necessary rest at cutoff points corresponding to semi-fixed conditions. We say that if the pressure changes slightly, do not make any change in draft or fuel supply; it may come back, and if it does we have avoided making one disturbance in furnace conditions which it was not necessary to make, and, therefore, we are leaning a little closer to a fixed furnace condition.

Undoubtedly a regulator should operate over the widest pressure range that it is possible to have in order that the least disturbance in furnace conditions will be effected, and a regulator should maintain its setting as long as possible, and then assume a new position which will correspond to a new boiler rating necessary to maintain the load.

No draft regulator can be expected to supply the proper amount of air for best combustion unless it controls both fuel and air supply, and then only in case the variations in fuel and air supply are consistent with load variations for the entire cycle of control.

Air flow through the boiler furnace should be in direct ratio to the fuel supply and this ratio should only be varied when the grade of fuel is varied, that is to say, a poor grade of fuel may require more air than a good grade of fuel. The ratio of fuel to air once being established it is desirable to maintain the ratio for the entire range of control or for the entire range of load fluctuations.

It is desirable to maintain steam flow and air flow at as near a constant ratio as possible for the entire range of control, and if the regulator which controls the air flow has uniform increments of action for uniform increments of steam pressure variations, it will be impossible to keep the air and steam flow together. Take it in the case of damper control, the first closing movement of the damper has very little effect in throttling the gases, the flow of gases being represented by a curve and not by a straight line.

In order that the variable characteristic of the gas flow may be compensated for, and that gases may flow in uniform increments consistent with steam flow, it is necessary to arrange the regulator so it will have variable increments of action for uniform increments of steam pressure variations. Or, in other words, uniform variations in steam pressure should produce uniform variations in draft and not uniform variations in damper movement.

These variable characteristics are found not only in damper control but in forced and induced draft fans. They also have a variable blowing characteristic which is represented by a curve. This is also true of throttling valves used for the automatic control of steam driven fans, which also have variable flow characteristics.

These variable factors are easily determined by means of draft gages and boiler flow meters, and should be effectively corrected by means of regulating equipment having variable increments of control.

BECAUSE SOME of the stationary engineers working for the City of Denver quit the old Union and formed one of their own, those who remained with the old organization asked Mayor Bailey to discharge the "non-unionists." Mayor Bailey called the men together and informed them that there would be no dismissal on that account and to work in the future as they have in the past and forget the rest of it.

Fundamentals of Power Transmission by Belting

ELASTICITY, PULLEY GRIP AND ARC OF CONTACT ARE IMPORTANT FACTORS. BY LOUIS W. ARNY*

IN THE ideal belt drive, wherein the belt runs horizontally, pulling on the bottom, and in the modifications of it driving at an angle, certainly as much as 45 deg., and perhaps more, the belt still pulling on the bottom, we have a favorable illustration of the value of elasticity in the belt. Where the belt is put on the pulleys under the usual tension of, say, 288 lb., or thereabouts, when the belt is in a state of rest, the tension is fairly divided between the two strands of the belt,

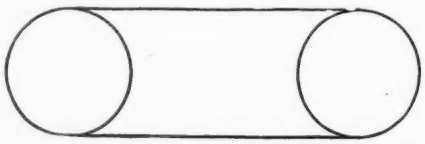


FIG. 1. TENSION DIVIDED EQUALLY BETWEEN THE TWO STRANDS WHEN BELT IS AT REST

as illustrated in Fig. 1, if the shafts, or either one of them, are free to revolve. In the case of a belt of ordinary size, put on with belt clamps, the stress occasioned by the clamps usually is sufficient to revolve either one of the shafts to the extent of producing an equilibrium between the two strands of the belt, and the total tension of the belt is divided approximately evenly between the two strands. In the case of a large belt, say a heavy main driver, over an engine and a long and heavy countershaft, this might not be exactly true, because it may be impossible to supply sufficient strain by the clamps either to slip the belt or to turn either shaft, so that the full strain of the clamps is not communicated to the other strand of the belt, and the tensions may be different.

When motion is applied, if the belt be of leather, the tensions probably will be slightly changed, even before the load is applied, the tension on the bottom side increasing slightly, and the tension on the top side decreasing slightly, but when a sufficient load is applied, there gradually occurs a complete change, the bottom side becoming more taut, and the top side increasing in length and becoming loose and dropping considerably from a straight line drawn across the face of the two pulleys. Apparently, as in Fig. 2, the tension which existed in this top strand in a state of rest has disappeared, or nearly so, and its total tension probably is not any more than that occasioned by its own weight. The tension on the bottom strand, however, has been increased by the application of the load, and whatever the load may be, it is being carried by this bottom strand. The carrying of this load by the bottom strand is dependent, therefore, upon the adhesion of the belt to the pulley, because there no longer is a tension on the top side to hold the belt in place. The belt is appreciably longer than it was when standing, and without this quality of adhesion, or pulley grip, it simply would slide around the pulleys and the tension on the bottom ply would be lost. With a good leather belt this tension, however, is not lost, because the pulley grip is of sufficient intensity that the belt does not slide around the pulleys. It is obvious, then, that pulley grip is a dominant factor of transmission. In belts which do not possess a natural pulley grip, it becomes necessary to supply something that will become its substitute, at least to an extent, hence the use of belt dressings, and the maintenance of a high tension on the top side. Some form of pulley adhesion may be supplied to them for a time by the application of a dressing but any advantage which they may acquire from such application is more or less temporary.

Power transmitted by any belt is the difference between the tensions of the top and bottom strands. From the total tension of the bottom side must be subtracted the total tension of the top side. If, to prevent the belt from slipping, it be necessary that the original slow running tension on the top side shall be maintained, this must be deducted from the tension on the bottom side to secure the effective pull. This tension on the top side becomes a back pressure which the tension of the bottom side must overcome, and the maintenance of this tension, then, becomes a part of the cost of transmitting the load by this belt. If the same load can be transmitted by another belt without maintaining this tension on the top side, it is evident that it will transmit a larger load, or will transmit the same load at a less expense. The belt, therefore, whose pulley grip is sufficient to carry its load without slipping excessively, and which has sufficient elasticity to elongate on

FIG. 2. WHEN THE BELT IS IN MOTION AND A LOAD IS APPLIED THE UPPER STRAND SAGS

the top side to an extent to cancel the tension of that side, will operate more favorably, and more efficiently, than the belt whose adhesion to the pulley must be maintained by a continuance of the tension on the top side.

Factors of economical and efficient power transmission by belting, therefore, are pulley grip and elasticity, and any belt to operate efficiently must possess both these qualities. This, then, becomes a measure of belt efficiency.

Properly prepared, the grain or hair side of leather makes a natural suction contact with the pulley.

Advantages of elasticity in a belt are entirely separate and distinct from that other advantage of the increased pulley contact which is a result of the elongation of the top side of the belt. Pulley contact is one of the important factors of power transmission, hence the more of the arc of the pulley that is covered by the belt, the more will be the power transmission; and the longer and looser the top strand of the belt may be, the more of the arc of the pulley will be covered. The value of pulley contact as a factor is, at least, in proportion to the degrees of arc of contact. Some good authorities claim that it is even greater, but this is a subject which remains to be investigated.

*Secretary, the Leather Belting Exchange.

Adapting Meters to a Growing Power System

In 1912, the Peninsular Power Co. built its Twin Falls Station for the purpose of supplying power over 66,000-v. lines to the Iron River, Alpha, Crystal Falls and Florence mining district. Provisions were made at that time to handle a relatively small load to the Iron Mountain over duplicate 6600-v. lines and a graphic meter with a 600-kw. scale was used on these feeders as well as a watthour meter. These lines were connected to the end of the main generator bus as shown at the left in Fig. 1. Additional mining and city lighting

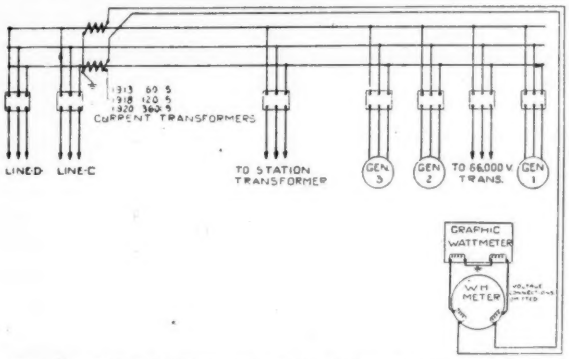


FIG. 1. CONNECTIONS AT TWIN FALLS STATION SHORTLY AFTER ERECTION

load were soon obtained on this end of the system so that the peak load on these feeders was over 600 kw. Current transformers with ratios of 120 to 5 were then installed to replace the 60 to 5 current transformers formerly used. The wattmeter readings were then multiplied by two while paper with a 1200-kw. scale was supplied for the graphic meter.

In 1920 the load had again increased so that the 6600-v. lines were reinsulated for 13,200 v. and a substation with necessary transformers, etc., was built adjacent to the power house. An oil switch of larger capacity replaced the line switch D (Fig. 2), this switch supplying power to the transformers in the substation annex while the line switch, C, was used to supply power to a new 6600-v. line. When these changes were made, 360 to 5 current transformers were installed on the bus so that the graphic meter could register 3600 kw. and the watthour meter readings were multiplied by six.

Because of the increasing use of power, it was now necessary to install an additional bank of three 833-kw. transformers in the substation annex to supply power to what is called the southeastern district of this system. Another 6600-v. transformer switch was connected to the generator bus as shown in Fig. 2. Current transformers with ratios of 600 to 5 on this circuit have their secondaries paralleled with 600 to 5 current transformers which replaced those with the 360 to 5

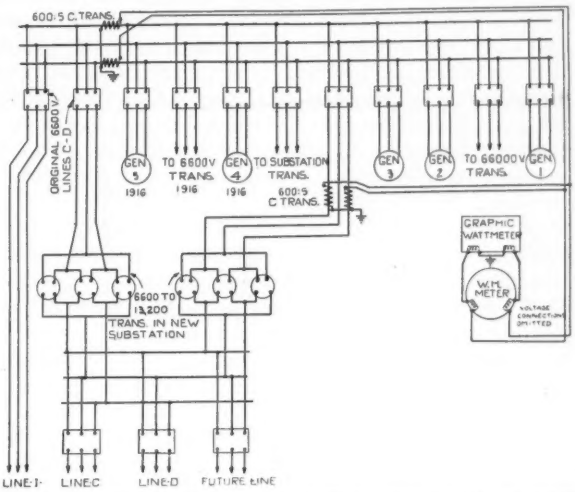


FIG. 2. REVISED CONNECTIONS AT THE TWIN FALLS STATION

ratio on the main bus. The same graphic meter is now capable of registering 6000 kw. while it is only necessary to add a zero to the reading on watthour meter.

In this way meters originally intended for a small load now accurately register the total load delivered to the southeastern district over one 6600-v. line and two 13,200-v. lines as well as the future 13,200-v. line.

It might be well to add that two additional hydroelectric plants supply power to the 66,000-v. lines of this system, relieving the Twin Falls plant of most of the original 66,000-v. load as well as taking care of the increasing 66,000-v. load. The replaced current transformers are all in service again, as it was easy to find a place for them on a growing system.

L. W. Wyss.

Trap Installation

In the Jan. 15 issue on page 147 there is an item under the heading "Trap Installation" which refers to the installation of steam traps for the drainage of a steam-separating receiver. Several contributors state that it is either wrong or unsafe to place a steam trap at any other than the lowest point of the apparatus to be drained, whether it be a receiver or a pipe coil. The good reasons given are not only backed up by theory, but are absolutely true in everyday practice, where safety and economy are observed. It was not stated by anyone that a steam trap could not be located at a high point, but it was emphasized by all that it should not be done.

Unfortunately these view points are condemned by a sweeping assertion made in the Jan. 15 number. The single instance given as an example does not, however, change the fact that in order to drain away the water by gravity a steam trap must be placed at the lowest point on the equipment. My original contribution, as well as those of others, made it clear that the steam trap placed at a higher elevation would work all right; but the apparatus it was supposed to drain would be under certain disadvantages, as given on page 924 of the Sept. 15, 1922 issue of Power Plant Engineering.

To correct the wrong impression that might be created in the minds of some by the item on page 147 of Jan. 15 issue is the object of this writing. The case illustrated is typical of many installations that are wrongly made sometimes through lack of better knowledge, but more often through force of circumstances, such as insufficient headroom, physical arrangement of piping or apparatus, and so forth. Just because there are such installations in existence does not mean that they are examples of best practice. Because they do not cause trouble or inconvenience in some places, does not mean that they are safe for most conditions. Due only to limited experience would anyone wilfully state that any style or make of steam trap will give the desired drainage results when placed above the apparatus to be drained. The style or make of steam trap has nothing whatever to do with the point illustrated on page 147. Leaving out the question of water-logging, whether it is an undesirable feature or not, it is easy to see why a steam coil can be made to circulate even though the steam trap is high above the drainage point.

In the case mentioned, there is a steam pressure of 75 lb. and if this discharges through the coil and trap into a return line having a pressure of, say, 15 lb., then there is a differential of 60 lb., or 120 ft. head, which is the height to which the condensation could be lifted in this particular case. Nothing extraordinary has been done in raising water 18 ft. with a steam pressure of 75 lb. driving it.

As to the steam trap in the particular case illustrated, nobody can claim that it served to drain away the condensation. What it did do was to prevent steam from blowing directly into the return line, thereby saving trouble from possible backing-up, water hammer and sluggish circulation on the rest of the piping system.

In steam plants a steam trap is an important appliance, and if used properly will give good, economical results and frequently will help in circulation and also prevent waste of steam, which of course means coal; but whenever a pipe, coil, kettle or machine is to be drained there is only one thing to do, and that is to locate the steam trap as near to the drainage point as possible and below it, to secure the full benefit of removal of condensate. M. William Ehrlich.

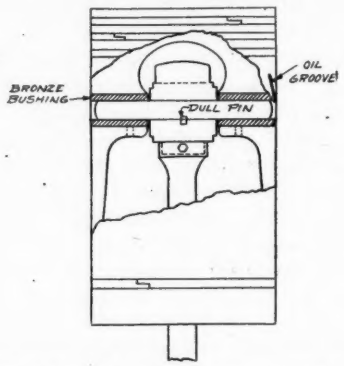
Wristpin Trouble Overcome

We have a 100-hp., two-cylinder, vertical gas engine which gave us extensive wristpin trouble. So unhandy it was to get at them that it was necessary to take the pistons out to adjust the wristpin bearings. They were of the common take-up wedge type and to get a wrench to do the work was next to impossible.

Pins became loose in the pistons and in tightening the set screws the threads in the pistons were stripped, so we decided not to put in large size screws but to get the trouble settled for good.

Pistons were sent to a machine shop to have the wristpin holes bored out and standard size phosphor bronze bushings pressed in, new pins made of hardened and ground tool steel and oil grooves cut on the pistons so as to catch oil from the cylinder walls.

This work really settled the trouble. The pins have more than twice the previous bearing area. They get much more oil this way than they did when they depended on the occasional splash of the connecting rods,



GAS ENGINE PISTON ON WHICH WRISTPIN TROUBLE DEVELOPED

as they were fed by a sight oiler and were not getting an oversupply so as to splash oil 4 ft. away.

Take-up wedge screws were replaced by a next larger size, a dull pin was placed half in the old piston pin brass, half in the wristpin and the brasses were locked tight. This style of wristpin bearings is used successfully in automobile engines so we have good reason to expect it will last as well in our engine.

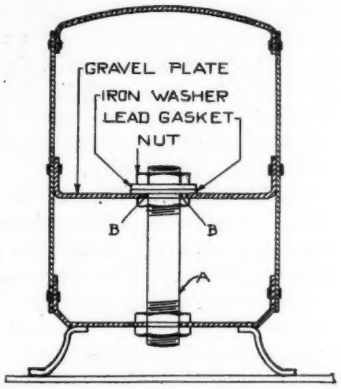
Chas. Labbe.

Repair of Water Filter

In a large steam laundry there is in use a water filter for filtering water used for washing and for other purposes. Gravel of different grades is used in the filter, For some time it had been noticed that there was gravel in the water line between the filter and washing machines, etc. There are automatic valves on the washing machines which shut off the water when it has reached a certain predetermined height in the washer cylinders where this gravel caused much trouble by getting in between the valve disc and its seat, thus preventing closure at the proper time.

At first it was thought that some of the water nozzles were loose or broken at the gravel plate through which the water passes before it gets to the gravel, and it was thought that these broken or loose water nozzles allowed some of the gravel to work through; but after opening up the filter and removing the gravel from the water nozzles and gravel plate, it was found that none of the nozzles were loose nor broken but that the gravel and water had enlarged the hole around the bolt "A," as shown in the accompanying sketch, where it passes through the gravel plate at B, B. This allowed the gravel to work through into the water main and then into the washing machine valves.

As there was not enough time to have a new gravel plate placed in the filter, a quick repair was made, which proved quite satisfactory. A washer was made from a piece of ½-in. flat iron, the hole being of such size that it had a tight fit over the bolt, A, and the

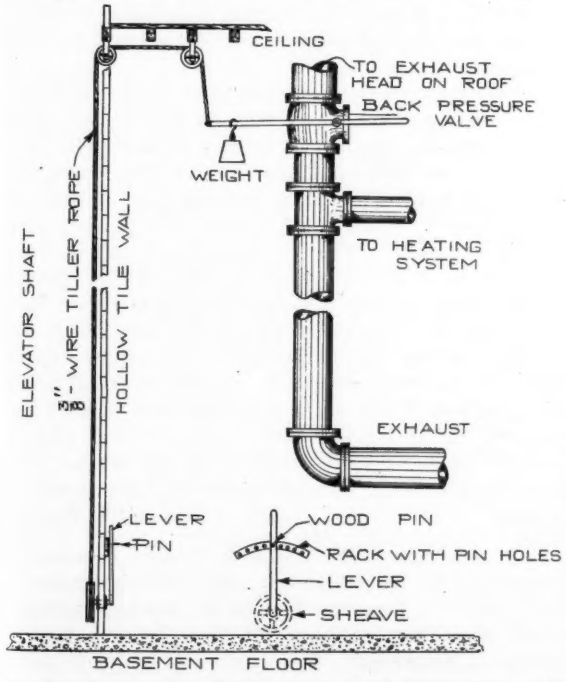


SECTION OF FILTER SHOWING HOW SPACE AROUND BOLT WAS FILLED

outside diameter was made large enough so it covered the enlarged space around the bolt. A lead gasket was then placed over the bolt next to the gravel plate, then the iron washer over the lead gasket and the nut, which was drawn up quite tight, so as to compress the lead gasket onto the gravel plate. H. A. JAHNKE.

Remote Control for Back Pressure Valve

IN AN 11 story building, steam was taken from the 14-in. exhaust, on the top floor, to heat the building, and the back-pressure valve was located above that point,



ARRANGEMENT FOR CONTROLLING BACK PRESSURE VALVE NEAR ROOF FROM A POINT IN THE BASEMENT

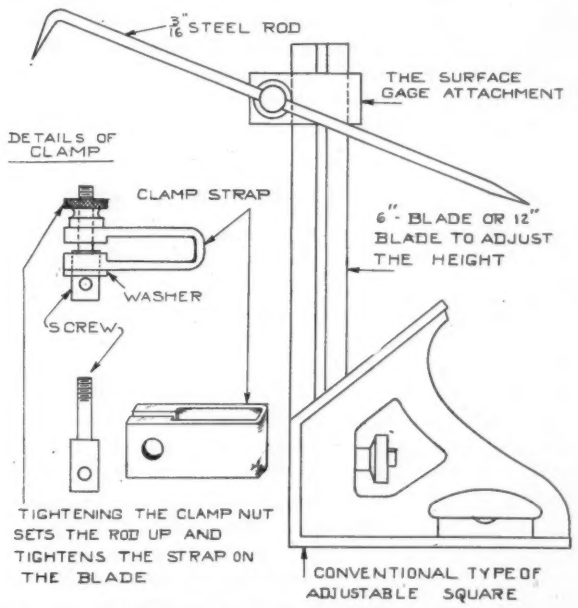
near the ceiling. At times, either because of radiator valves being closed, or of an increase in load on the prime mover the exhaust pressure would run up, necessitating a trip to the top floor to adjust the weight on the lever of the back-pressure valve. Sometimes it was necessary to make this trip several times a day.

To obviate this difficulty, a device was made to adjust the exhaust pressure from the engine room floor. Owing to stock being piled on the several floors, a straight, vertical lead for the cable could not be obtained; but by hanging two sheaves from the ceiling, as shown in the accompanying sketch, a ⅜-in. wire tiller rope was carried 6 ft. to an elevator shaft, and thence to the basement to another sheave on a short raft extending through the hollow tile wall. On the outside of the wall, a lever secured to the shaft and a circular wooden rack with holes for a pin was secured to the wall. When it is desired to relieve the pressure, it is only necessary to change the lever and secure it with the wooden pin. Additional weight on the lever was necessary, to compensate for the added weight of the cable.

M. M. BROWN.

Attachment Converts Adjustable Square to Surface Gage

TAKING advantage of the flat surface of the head of an adjustable square, a serviceable surface gage attachment is made as is shown herewith. The gage rod is of

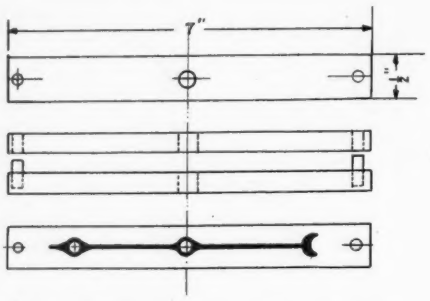

3/16" STEEL ROD
THE SURFACE GAGE ATTACHMENT
DETAILS OF CLAMP
CLAMP STRAP
6" - BLADE OR 12" BLADE TO ADJUST THE HEIGHT
WASHER
SCREW
TIGHTENING THE CLAMP NUT SETS THE ROD UP AND TIGHTENS THE STRAP ON THE BLADE
CONVENTIONAL TYPE OF ADJUSTABLE SQUARE

EASILY MADE SURFACE GAGE DOES NOT CROWD TOOL KIT

the usual diameter, around 3/16 in., with one straight point and the other a bent point. This is secured with a pivoting clamp screw. A strap to secure this point to the blade of the square is adjusted for height and clamped by means of the same screw arrangement which clamps the rod. Apart from the saving in tool costs, this combination tool occupies less space in the tool kit. When used with the adjustable try square, it will attach to either the 6-in. blade or the 12-in. blade, when both lengths are available. This range of adjustment makes the gage suitable for large work, or gage work 18 or 20 in. above the face plate. G. A. LUERS.

Jig for Straightening Gage Hands

STEAM GAGE hands are hard to straighten when they have been bent or kinked through the little accidents which happen to them in spite of careful handling. It is easy, of course, to bend them with a pair of pliers



JIG FOR STRAIGHTENING GAGE HANDS

when kinked near the pivot button, but bends beyond that are extremely hard to get out. The accompanying sketch shows a practical little jig used by the writer. Two small strips of iron are trued and a hole large enough to accommodate the pivot button is drilled through the center of each. At each end a small dowel is placed. By laying the hand or pointer between the two strips and tapping with a block of wood, a badly kinked hand can be instantly straightened as true as it came from the factory. The jig was found handy on a gage repair bench where gages of all kinds came in for repair and adjustment. FRANK W. BENTLEY, JR.

Bearings, as Seen by a User

MACHINERY BEARINGS in general in use at the present time seem to be the weakest part of any machine with which I am acquainted. The fact that the machinery bearings of today are lined with practically the same material that was used by Isaac Babbitt over 80 yr. ago shows that little progress has been made by designers of machinery regarding the linings of bearings. They seem to think that if an alloy of approximately 88.9 per cent tin, 7.4 per cent antimony, and 3.7 per cent copper has withstood for more than 80 yr., it should answer the purpose for the present day; as to whether it does or not, a second thought seems never to have been given it.

There seems to be no question but that genuine babbit metal has given good service in days gone by, and in some cases is doing it today; but it seems as if some other lining for bearings could be had, perhaps not one that could be handled as easily as babbit, but one that would not run out under high temperatures, nor yet one that will cut or score the shaft, as do the brass and bronze bearings in use today.

I believe that the use of brass or bronze, with their high content of tin and zinc, should not be tolerated; yet at the present time we have to use them, if we want something that will hold up under high temperatures, even at the risk of having a cut shaft.

Perhaps one reason we have no better lining than we have is due to the peculiar fact that in combining two molten metals so as to form the third, we find we have a metal different from either of the originals, and with few exceptions we find a metal with a much lower melting point than either of the other two metals, perhaps also due to the fact that one metal only will combine a certain per cent of itself with a certain per cent of another, and if an excess of either metal is used, this excess will remain in its original state unchanged.

All metallurgists know this to be a fact; yet with the advancement that has been made along all branches of science, it seems as if someone would have discovered a bearing metal more suited for present day uses than those we have to contend with.

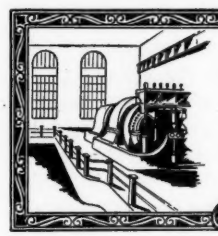
Bearings will be in use as long as the world goes round, and while roller and ball bearings have their many uses, there will always be a demand for a lining metal, and the metallurgist who discovers the ideal metal I have suggested should have his name placed high in the Hall of Fame for his discovery.

I am firm in my belief that sooner or later someone will discover a way of homogeneously alloying copper and lead, in proportion of, say, 50-50 or 60-40. Works on metallurgy tell us that copper base metals can be made to contain from 50-80 per cent copper, 5-10 per cent tin and 5-50 per cent lead. Why use the tin at all? I know one concern that is using a bearing metal of 73.5 per cent copper, 21 per cent lead and 5.5 per cent tin, yet they claim that the tin has a tendency to cut the shaft. Why not use a straight copper-lead metal? This would seem to be the ideal metal for motor bearings up to, say, 25 hp. and if a harder metal were wanted, add from 1-5 per cent nickel, keeping away from zinc and tin, as I do not believe that they are proper metals for a bearing lining.

As we have to use what we have until we get something better, however, let me add a few words regarding the heating and pouring of the tin- and lead-base metals.

One who uses scrap metal to pour a bearing is making a big mistake, as I claim that no metal after being poured once can possibly be as good as new metal; also, never mix two different kinds of metals, for unless they are known to be of the same formula (and in that case they wouldn't be different) nobody can possibly know without an analysis what he is putting in a bearing or what service it will give. Be careful of your pouring temperatures. While a metal can be poured colder or hotter than the proper pouring temperature, and a good-looking bearing will result, there is a proper temperature for pouring, which all manufacturers of metals will give you if you ask for it, and pour at that temperature, using a thermometer and not some piece of wood by which to judge the heat. If this is done, bearings will give better service than if they are poured hit or miss. CHAS. N. SHAW.

EDITOR'S NOTE: While Mr. Shaw may be somewhat inaccurate in his statement that little progress has been made in the manufacture of bearing metals, it would seem that in his article there is some food for thought. Apparently, the question of properly fitting a bearing metal for the service that the bearing has to give is one that is not thoroughly understood by many of our engineers and it is hoped that Mr. Shaw's statements and questions will bring forth some comment on the subject.



PROBLEMS IN OPERATING POWER EQUIPMENT

Suction and Discharge Valves Lift on Water Pump

OUR DUPLEX feed water pump has recently been giving us some trouble. At the beginning of each stroke, the piston jumps. The water end was opened up and inspected. The four suction and four discharge valves were found to be in fairly good shape, but new ones were fitted to be on the safe side. They were set so that the lift of the discharge was greater than that of the suction valves. When the pump was put back in service, it ran as well as when new. Did the difference in the lift of the two sets of valves correct the trouble? Should valves always be set in this manner?

B. F. G.

Lead on Vertical Engines

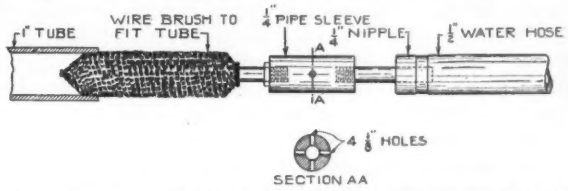
SOME TIME ago, while taking an engineers' examination, I was confronted with the question, "What general principle applies in determining lead on large vertical engines?" Where no auxiliary cylinder is provided to take care of the weight of the piston, piston rod, crosshead, etc., the practice is to allow for a greater lead on the up stroke, but the question is how much should this lead be? How is the amount determined? Is this simply a matter of experience or cut and try, or is there some way in which it can be found beforehand? Any information on this subject, from Power Plant Engineering readers, will be highly appreciated.

R. O. M.

Cleaning Condenser Tubes

IN THE Jan. 15 issue of Power Plant Engineering, on page 144, W. M. M. inquires as to the best way of cleaning surface condenser tubing. The accompanying sketch is of a cleaner which I made and which has been giving me excellent results, having increased my average vacuum from ½ to 1 in. In using this cleaner, it is unnecessary to remove the large head on the condenser; it is sufficient to take off only the manhole plate in the head. After attaching the hose to a city water supply, a man can go inside and wash the tubes out in a comparatively short time. The brush should be pushed through slowly, however, to be sure that all the mud is taken out. It is well also to make the hose so that the operator may know when the whole length of tube has been traversed.

Before I hit upon this method of cleaning, I used to use a length of ¼-in. pipe instead of the hose and it required about four or five days to finish the job. During this time the machine was out of commission. When the hose is used and only the manhole cover instead of the entire head is used, the machine is only down during the actual cleaning period and in an emergency may be put back into service in the length of time required to replace the manhole cover. The time required for cleaning with the hose is about three shifts for an 8000-sq. ft. condenser. If need be, the machine can be put in operation during a peak shift and then stopped for cleaning again when the load is light.



CONDENSER TUBE CLEANER FITTED WITH HOSE INSTEAD OF A LENGTH OF PIPE

As indicated in the sketch, the brush is made to fit a 1-in. tube. The hose is a nominal ½-in. size and has an external diameter small enough to allow it just to slip through the tube.

ROBERT BENSON.

IN RESPONSE to W. M. M.'s request for information on cleaning condenser tubes, in the Jan. 15, 1923, issue, I offer the following:

We are troubled with mud blown into our open spray pond in the form of dust, and with scale, our circulating water being unusually hard, about 30 grains of incrusting solids to the gallon.

About every four weeks we clean the scale from the condenser tubes with hydrochloric acid, mixing a 10 per cent solution in a tar-lined concrete tank and circulating it through the tubes by a steam pump. The strength of the solution is determined by the methyl orange color test and tests are made at regular intervals. Acid must be added from time to time as the strength of the solution drops. The acid solution is circulated through the tubes for from 9 to 12 hr., after which the condenser is drained, the heads removed and the tubes washed out. The only apparatus required is the tank mentioned (a couple of barrels connected by a nipple will do), some sort of pump and the necessary piping. Results are excellent.

To clean the mud out, we take both condenser heads off and wash the mud from each tube with a hose, using a piece of ⅜-in. pipe for a nozzle. The nozzle is held in each tube for a few seconds to insure thorough cleaning. We use a water pressure of 25 to 40 lb., depending on whether oil is mixed with the mud as it requires more pressure and water to remove an oily mud.

We have used this method for the past 2 yr. with good results and it has the added advantages of not damaging the condenser tubes, and of being quick. One man can remove both heads, wash every tube and replace both heads in 4 hr. (Our two condensers have about 1600 tubes each.) Our plant is in continuous service

and we wash each condenser every Sunday. We get our condensers good and clean and the difference in vacuum amounts to several inches.

We still have our mud troubles, but our scale troubles have been practically eliminated since the installation of our water treating plant. The condensate which formerly went to the boiler feed water heater now goes to the cooling pond and the pure water deposits no scale in the condenser tubes. The treated water from the softener goes to the boilers. Of course, we lose the heat in the condensate; but inasmuch as our boilers are fired with coke oven gas at a flat rate, it makes no difference. A. L. CONWELL.

REFERRING TO W. M. M.'s inquiry in the issue of Jan. 15, on the subject of cleaning steam condensers, the writer has had considerable opportunity to observe this work on surface condensers under large steam turbines. Various types of scrapers have been employed on these machines, of which perhaps the most effective is a brush formed of spiral wire springs, which is fastened to the end of a rod and pushed through the tubes by hand. Other effective cleaners are of plunger design, and are forced through the tubes by water pressure. Cleaners of one of these types appear to be most satisfactory in the long run where it is desired to do the work quickly and thoroughly.

If frequent cleaning is required, a rig must be provided for facilitating the removal and replacement of doors at one end of the condenser and their disposal during the cleaning period. With such provisions, a gang of 6 or 7 men with a foreman should be able to clean 4000 or 5000 tubes within 8 hr., counting from the time the condenser is taken out to the time it is returned to service.

As to the frequency of cleaning and the effect on vacuum and on circulating water required, these are matters which depend to so great an extent on local and immediate conditions that no approximate figures can be given. In a plant where the quality of circulating water is unusually bad, the writer has known cases where cleaning was necessary after less than 20 hr. run of the circulating pump, and of others where the pump has run for 500 or 600 hr. before the vacuum began to fall off noticeably on account of fouling of condenser tubes. In plants where fresh, pure water is available for cooling purposes, these figures might be multiplied many times. Frequency of cleaning will depend upon the loss of vacuum due to fouling of tubes; but the fact that vacuum drop will also occur from other causes, such as the condition of the air pump and air leakage into the condenser, must be constantly kept in mind. The extent to which it is advisable to go in cleaning will of course be governed by the commercial value of vacuum under given circumstances, which must be figured out for each individual case. J. L. W.

Inexpensive Boiler Covering

REGARDING THE practice of covering the boiler top with ashes as mentioned in an article on inexpensive boiler covering that appeared in the Jan. 15 issue, it is true that the ashes will not corrode the metal if they remain dry, but there is always the possibility that they will become damp from steam or water leaks. In that case it is likely that they will cut a hole in the boiler. It is nonsense to talk of the fire removing the constituents that are injurious to iron or steel.

We have many pipe lines laid in the ground in the mill yard and the yard men have a habit of leveling up the yard with cinders. This causes much trouble through corrosion; rain water apparently combines with the sulphur in the ash to form sulphuric acid which seeps down through the looser earth of the trench to the pipe and, I can assure you, eats it away. The same thing will happen to a boiler if any water gets to the ashes. I have had a ¾-in. pipe destroyed in 6 mo. where a coating of cinders was applied soon after the pipe was laid. Lines where no cinders are spread give little trouble. J. O. BENEFIEL.

Third Class Engineers' Examination Questions and Answers

WHAT IS the purpose of a counterbore on an engine?

Ends of the cylinder are counterbored so that the piston will not form a shoulder at the end of the stroke. The edge of the first piston ring just passes over this counterbore. In centering the piston, measure from this bore, as there is no wear there and the measurements can be depended upon.

2. What is the purpose of the tail rod on a simple pump?

On a pump the tail rod is a continuation of the valve stem, and is for the purpose of eliminating the unbalanced area of the valve stem. On most of the old simplex pumps there was no tail rod, and due to this unbalanced area of the valve stem, at times the valve stem would vibrate at the end of its stroke.

3. How does oil get into a boiler and how can it be gotten out?

Oil gets into the boiler usually from the heating system where an engine is used, and the oil separator has not been properly taken care of, or is not large enough for the work. It may be set too close to the engine where the steam has too great a velocity. To get the oil out, it has been my experience that soda ash will give the best results, either by using some every day or boiling the boiler out with it, leaving the boiler open to the atmosphere while this is being done.

4. What is an oil separator and how does it function?

An oil separator is used to separate oil from exhaust steam so that the condensate can be used in the boiler. It is placed in the exhaust line, about 10 ft. from the cylinder. In some cases, there is a baffle plate that is stationary, and the oil will collect on that and drop down; in other makes, there are baffle plates that can be removed and boiled with caustic soda to clean them. There should be an oil trap or an entrance to some sewer or open discharge. It is important that this trap be kept in working condition at all times as boilers may become seriously bagged due to the fact that the oil separator discharge was plugged.

5. How is wear taken up on a marine type bearing?

With a marine type bearing on a center crank engine, lost motion is taken up by taking out shims. To do this take out the cotter pin in the end of the bolt, loosen check nut, then loosen main nut. This will allow the necessary shims to be taken out, after which the nuts may be tightened again.

6.. When should a shim be put back of the crown brass on a strap end rod?

If the key had been driven down as far as possible so that the lost motion could not be taken up, put a shim back of the crown brass. The key would have to be driven up first, but this will bring the key up to a higher position so that more lost motion can be taken up.

7. What will cause an engine to pound?

Pounding in an engine may be caused by several conditions, such as too much lost motion in any bearing, engine out of line, piston loose on the piston rod, piston rod loose in the crosshead, unequal cutoff, not enough or too much compression, and crosshead guides not set parallel. F. C. E.

Materials Used in Boiler Construction

SPECIFICATION OF materials and their use in boiler construction is a question of prime importance in boiler inspection work and should be of interest to anyone concerned with boilers. The questions and answers presented herewith contain examples of such information as should be easily available for either the inspector or operator.

1. What is the objection to high tenacity in boiler steel?

Steel of high tenacity is more sensitive to changes of temperature, and it has been found to have a greater tendency to crack under high temperatures.

2. What should be the tensile strength of steel as used in boiler construction?

	Flange Steel	Fire-box	Extra Soft Steel
Mass. Rules	55,000–65,000	52,000–62,000	45,000–55,000
A. S. M. E. Code	55,000–65,000	55,000–63,000	

According to Massachusetts rules flange steel should be 55,000-65,000; fire-box, 52,000-62,000; and extra soft steel, 45,000-55,000. The A. S. M. E. code specifies flange steel 55,000-65,000 and fire-box steel, 55,000-63,000.

3. Where is cast iron used in the construction of boilers?

Cast iron is not used in the construction of boilers except where low pressures are carried. In old boilers the mud-drums and headers were often cast iron, but experience has shown that this metal is not suitable for the pressure parts of boilers.

4. What is the Massachusetts rule relative to cast iron construction?

Boilers wholly of cast iron installed before 1915 shall be allowed a pressure not exceeding 25 lb. Boilers wholly cast iron installed since 1915 shall be allowed a pressure not exceeding 15 lb. Boilers equipped with cast iron pressure parts shall be allowed a pressure not to exceed 160 lb.

5. What is the objection to cast iron construction?

It is impossible to know the exact internal condition of the casting. There is also considerable trouble experienced due to sudden changes in the temperature of the metal, causing cracking.

6. What is the great advantage of cast iron construction?

It is practically impervious to corrosion.

7. What is the tensile strength of cast iron as used in boiler construction?

Eighteen thousand lb.—Massachusetts rules.

8. What is the strength of rivets in single and double shear?

According to Massachusetts rules:

Iron rivets in single shear	38,000 lb.
Iron rivets in double shear	70,000 lb.
Steel rivets in single shear	42,000 lb.
Steel rivets in double shear	78,000 lb.

In the A. S. M. E. Code slightly higher values are allowed.

9. What is the objection to cone-shaped rivet holes, as caused by punching the plates?

Steps, or zigzag holes are formed, tending to prevent the rivet from properly filling the holes.

10. What is an indication of poor riveting?

Rivets not in line longitudinally, and unequal pitch are indications of poor riveting.

11. What is the prime requirement in the spacing of rivets?

Rivets must be spaced close enough to permit proper calking of the seam.

12. Which is the better, light or heavy blows with the riveting hammer?

Heavy blows are better as this affects the rivet throughout its length.

13. What is the maximum efficiency of a rivet?

A rivet that will crush the plate out in front of it before it will shear has reached its maximum efficiency.

14. About what temperature should rivets be for driving?

Rivets should not be more than cherry red, as beyond this point they will burn.

15. Would there be any difference in the thickness of the front and back heads of a boiler?

The front head is sometimes made 1/16 in. thicker, to compensate for the weakening of the head by cutting the manhole under the tubes.

16. Why is it not practical to flange the front head in?

The rear head can be calked in the plate edge, but due to the dry sheet extending beyond the head at the front head of boiler, no calking edge would be provided.

17. What factors should be given consideration in laying out the tube holes in a horizontal return tubular boiler?

The matter of circulation is perhaps the most important as too close spacing of the tubes will retard the circulation, tending to make an inefficient boiler.

18. What hydrostatic pressure is or should be applied to new tubes in the shop before they are used in boiler construction?

Tubes under 5 in. diameter should stand a hydrostatic test of 1000 lb. applied internally. Tubes 5 in. or over should stand an internal hydrostatic test of 800 lb.

19. What are stay tubes?

Stay tubes are heavier tubes than those commonly used. The ends are threaded and shallow nuts are fitted on. This type of stay has practically gone out of use as experiment has shown that the holding power of expanded tubes is equal to the load the tube must carry.

20. What are upset tubes?

Upset tubes are tubes in which the thickness at the ends is increased by upsetting the end. They are used extensively in marine boiler construction. In some types, the enlarged end is threaded and screwed through the sheet, while in others the enlarged end is expanded only.

21. What is the advantage of upsetting tube ends?

Upsetting tube ends gives extra stock at the place in the tube where failure is most likely to occur.

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Tempering Coal Has Value

Scientific practice in the burning of coal has advanced remarkably during the past decade. Draft gages, gas analyzers, combustion control systems, ignition arches, tuyeres for admission of air at specific points in the furnace, all have their places in aiding the fireman, and sufficient experiments have been conducted so that he knows what to expect when one or another of these conditions are changed.

When it comes to the tempering of coal, however, scientific data is decidedly lacking. Each fireman apparently has his own views on the subject and seldom do these views coincide. The characteristics of the different kinds of coal, the type of stoker or grate, the furnace design, thickness of fuel bed, the temperature of the furnace, have all been recognized as factors to be considered when determining how much moisture should be added to coal; but the definite effect of any one factor has never been determined.

Engineers will, therefore, welcome the information given by Mr. Marsh on other pages of this issue which is the result of quite exhaustive tests to determine the effect of moisture on the flow of air through the fuel bed. Although Mr. Marsh presents in this article some extremely valuable data, it is to be hoped that further investigation will be carried out to determine the effects of varying quantities of moisture on other furnace conditions such as sifting through grate, loss to ashpit, furnace temperatures, rapidity of ignition, slag on boiler tubes. The practical fireman has long recognized an advantage in tempering coal; it is now the problem of the scientific engineer to determine when coal is properly tempered for the various conditions met in practice.

Short Transmission Line Design

One of the most important problems that the electrical engineer of today has to deal with is that of transmitting electrical energy from the point of generation to the point of consumption. The phenomena with which he has to deal, especially when the distances involved are long, is extremely complex, and as a result transmission line design has remained a matter requiring rather high specialized training. In cases where such long lines are involved, however, there is usually ample technical talent available so that the complexity of the problems present no serious difficulty.

In the design of short transmission lines, it is true, the solution of the problem is less involved; it nevertheless requires a definite knowledge of certain fundamental principles, and unless the engineer in charge of the work is in possession of this knowledge, the solution of the problem is apt to prove a stumbling block. A trained electrical engineer would, of course, experience no difficulty; but many times, particularly in the case of an industrial plant, the electrical work is under the supervision of a mechanical engineer or a practical electrician who has had no special training in theoretical electrical engineering, and when the problem of constructing a new transmission line arises, he finds information on the subject meagre and elusive. If the information is available, it is usually scattered throughout the general literature in such a manner as to be confusing.

In order to fulfill the need for a more comprehensive treatment of this phase of electrical engineering in a form sufficiently simple so that the average practical man can understand it, there will be published in Power Plant Engineering a series of articles dealing with the general subject of "Short Transmission Line Design," by E. K. McDowell, the first of which appears in the current issue. Mr. McDowell's long experience in this line has enabled him to handle the subject in a masterly manner, and in preparing this series of articles he has made a distinct and valuable contribution to electrical literature.

Another Year for Investigating Coal Industry

By continuing for one year practically the present working agreement between the coal mine operators and miners, in the tri-state competitive field of Illinois, Indiana and part of Ohio, which was the course decided upon at a conference held recently in New York, the country is spared a costly coal strike this year at least and until April 1, 1924, we have reasonable assurances that coal production will not be seriously interfered with. This delay will give the Federal Fuel Commission another year in which to study the coal mining industry with a view toward making a permanent settlement of the coal mining labor difficulties.

In the meantime the prices of coal will not be affected to any great extent so that, as in normal times, the coal user will do well to store a reasonable supply during the spring and summer months which will have a tendency to keep the mines working at highest efficiency and to stabilize market prices.

While it is regretted that a permanent agreement could not be put into effect, there is no certainty that this would reduce the cost of coal and high priced coal is better than no coal; furthermore it is some satisfaction to have the assurance that a buyers' panic is not likely to occur.

Off Duty

Time to knock off, boys! The whistle has blown and, for a brief interval, we will do well to forget the cares and worries of our work and turn our thoughts to other things for diversion.

Have you ever stopped to realize how important your Off Duty hours are to you? Do you know that they are just as important in the living of your lives as are your "On Duty" hours? They are just as essential to you as the safety valve is essential to the safety of your boiler; they provide an outlet, so to speak, through which you can exercise your natural desires or inclinations.

When we speak of natural desires and inclinations, however, we are treading on rather dangerous ground, and before we go any further, we must be certain that we know what these natural inclinations are. The tendency, in filling our Off Duty hours, is to follow, what generally appears to be the easiest, or, perhaps, the path which seems most agreeable. But it is here that we must exercise caution, for, what we think is the easiest path, is often the most trying.

Man is, of necessity, a creative animal, and his greatest pleasure in life comes from the proper exercise of his creative instincts. Now, this does not necessarily mean that a man who works diligently all day, must spend his Off Duty hours making Chinese toys out of cracker boxes in order to enjoy himself. To many men that would be the hardest kind of labor. It does mean, however, that the man who spends his Off Duty hours in absolute leisure (laziness, to be frank) is not getting the most out of life.

Make your Off Duty hours profitable, not necessarily profitable in a monetary way, but in a mental way. In your Off Duty hours lies your opportunity to broaden your outlook on life and to give vent to your natural creative instincts, which, only too often, are kept in suppression during your hours of labor.

This world is full of interesting things. Look about and find them. Find out what you like. If you like reading, the literature of the world lies open before you; the masters of all ages are there to give you counsel for the mere opening of their books.

Speaking of reading, however, let us whisper a word of caution. Be careful of what you read. Select your books carefully and be sure that they are not all novels. Most novels are luxuries, and you cannot afford to spend all your Off Duty hours in luxury.

If you don't care for serious reading, there are innumerable other paths open to you. Perhaps you like fishing. "To be sure," you say, "but we cannot always be fishing." Agreed; but, during the time you are not actually manipulating the fishing rod, why not try to learn something more about fish? Study their ways, their habits—find out how they live. Once you delve into the subject you will find a world of information which is yours for the asking.

These are merely suggestions, and they may not be applicable to your case. We didn't expect they would be. It is up to you to analyze yourself and find out in what way you would like to broaden your vision in the realm of universal knowledge.

Every man should have an avocation as well as a vocation, and the more different his avocation is from his vocation the more will he enjoy it. Dr. Oliver Wendell Holmes is not known to the world as a carpenter, yet in his Off Duty hours he loved nothing better than to spend his time in the basement of his home, where he had a complete carpenter shop.

"But," you say, "I don't care about following a new line of study or thought. I am well satisfied with my present state of mind—furthermore, when I finish my day's work, I am tired and want relaxation."

Very well, again we agree with you, but the question is, what do you call relaxation? Relaxation does not necessarily mean rest. To many people relaxation means sitting in an armchair after dinner, reading a newspaper, much of which might just as well remain unread as far as increasing their store of knowledge is concerned. To others it means some form of physical labor. It depends entirely upon the individual.

But, remember this, relaxation can be made profitable and it is up to you, personally, to find out how to make it so—we cannot tell you. If playing cards, or sitting in an arm chair reading the newspaper is what you consider relaxation, go to it; play cards and read the newspaper, BUT be sure you are right.

Insull Pictures North Illinois Power Development

SHOWS HOW CHANGES IN ENGINEERING PRACTICE HAVE AFFECTED GROWTH OF COMMONWEALTH EDISON AND AFFILIATED COMPANIES. EXPECTS CONNECTED LOAD TO DOUBLE IN NEXT EIGHT YEARS

IN AN address before the Western Society of Engineers at the dinner held at the Hamilton Club in Chicago on Feb. 1, Samuel Insull, president of the Commonwealth Edison Co., outlined the development of the central station industry in northern Illinois during the past 30 yr. and stated that plans now contemplated would practically double the present capacity of the central stations in this district and the estimated expenditure for this year is in the neighborhood of $35,000,000. Mr. Insull speaks of Greater Chicago, from an electrical distribution standpoint, as that district of northern Illinois extending from the Lake to the Mississippi River.

When in 1892 Mr. Insull became president of the Chicago Edison Co. its capacity was 3180 kw., which was less than half the central station development of the city; other smaller plants had a combined capacity of 3500 kw. making the total installed capacity of the city 6680 kw. The Adams St. Station was the first plant of the system and was put in service in August, 1888, with a capacity of 2860 kw. and served an area covering about ¾ sq. mi. The second plant was the Wabash Ave. Station which was put into operation in 1891 and served a territory covering 1 sq. mi. In this plant in 1897 was installed the first rotary converter manufactured for industrial use, to which incident Mr. Insull places considerable importance as it marked the beginning of satisfactory distribution of electric power to congested districts from a distant power plant generating alternating current.

It was the Harrison St. Station, installed in 1892 that marked the beginning of economical generation of power in Chicago. This plant was the first to employ marine type engines direct connected to dynamos and was the first of the system to run condensing.

With the growth of the demand for power and the development of more economical equipment came the building of the Fisk St. Station containing three 5000- and one 7500-kw. turbine generating units as the initial installation during the year from October, 1903, to October, 1904. This was one of the first installations of its kind and the units were the largest that had been put into use up to that date. In 1912, however, these turbines had become obsolete and were replaced by units of 12,000 kw. capacity; but no change was made in the boiler capacity, as it was about this time that it was found advisable to force the boilers above their rating.

Following the Fisk St. Station came the Quarry St. Station, then the Northwest Station, and about a year ago the Calumet Station was placed in service. This last plant is planned for a capacity of 200,000 kw. in six units. Naturally all of these stations are tied together electrically for distribution purposes, one noteworthy feature of the system being an underground cable carrying 33,000 v.

Ground is now being broken for what is to be known as the Crawford Ave. Station, located on the Drainage Canal. Plans for this station call for the installation of perhaps 10 units with a combined capacity of 400,000 or possibly 600,000 kw. The first two turbines for this plant have already been ordered consisting of one Parsons from England and one Westinghouse, the combined capacity being between 90,000 and 95,000 kw., and the third unit will be ordered from another American manufacturer within a short time. The plant will be designed for 600 lb. steam pressure.

As showing the progress in power plant development during the past 30 yr., Mr. Insull gave the sizes of generating units used in the various plants of the company as follows: In the Adams St. plant the individual units had a capacity of 80 kw.; Wabash Ave., 200 kw.; Harrison St., 800 and 3500 kw.; Fisk St., 5000 and later 12,000 and 35,000 kw.; Northwest Station, 30,000 kw.; Calumet, 35,000 kw.; Crawford Ave., 50,000 kw.

Another interesting comparison given is the steam pressures carried in the boilers of the different plants: In the Adams St. plant the pressure was 125 lb. per sq. in.; Wabash, 175; Fisk, 200; Northwest, 250; Calumet, 325; Crawford, 600 lb.; and it was stated that the company is now considering the practicability of boilers and turbines built for 1000 lb. steam pressure, experimental equipment having already been built.

Great advancements have also been made in the economy of coal for generating electric power. The Adams St. Station, the engines in which exhausted to atmosphere, required 12 lb. of coal per kw.-hr.; the Harrison St. Station, condensing, 6 lb.; Fisk, 2¾ to 2 lb., but more recently, 1.8 lb.; in the Crawford Ave. Station it is expected to reduce the coal consumption to 1.5 or 1.6 lb. per kw.-hr. Just what this advancement in economy of coal means, can be appreciated when it is considered that in 1922 the Commonwealth Edison Co. used 2,500,000 T. of coal, while under the methods employed 30 yr. ago the amount of coal that would have been required would have been between 15,000,000 and 18,000,000 T. to produce the same amount of power. This economy in coal, Mr. Insull attributes in large measure to improvements in stokers and furnaces, economizers, superheaters, large turbines and high vacuums, which average around 29 in. of mercury.

Transmission and distribution lines of the Commonwealth Edison Co. are connected in with the lines of the Public Service Co. of Northern Illinois and the Illinois Northern Utilities Co., so that, combined, the companies serve the entire northern part of the State of Illinois, covering an area of 10,000 mi. and serving a population of 4,000,000 people.

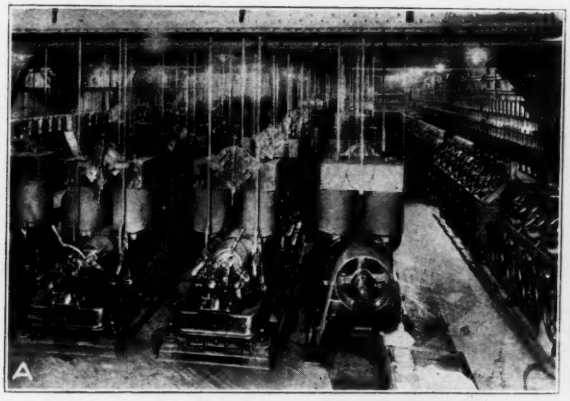
This combination is of advantage in securing a diversity of demand for power throughout the day. The maximum demand today for light, power, street railways, industries and steam railways, considering the railway terminals electrified, totals 1,110,000 kw. while the coincident demand is estimated at 959,000 kw. making the diversity 151,000 kw. Figuring the cost per kilowatt capacity of installed generating equipment at $100,

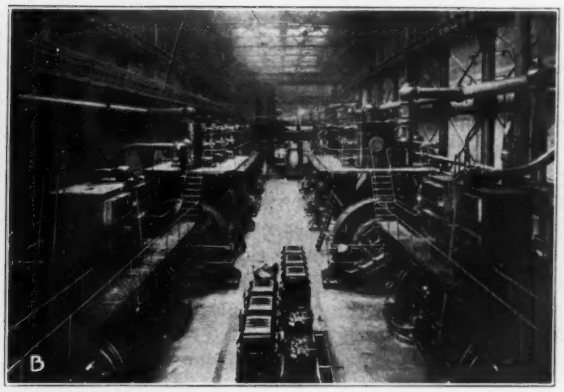
which is quite low, this diversity saves an investment of $18,120,000. If the country districts are included, the diversity is increased to 170,000 kw., or the total saving due to the diversity demand is around $20,000,000.

Present generating capacity of the connected central stations in northern Illinois, together with what will be put in operation during the present year, totals 1,021,600 kw. There is under contemplation an additional capacity of 1,600,000 kw. in this district, which in all likelihood will be sold in about 8 yr.

Under present conditions, good practice would indicate that a 10 per cent reserve in generating capacity above the maximum coincident demand is required. This, it is estimated, can reasonably be reduced to 5 per cent if the important generation stations in the district are connected by a high voltage transmission line.

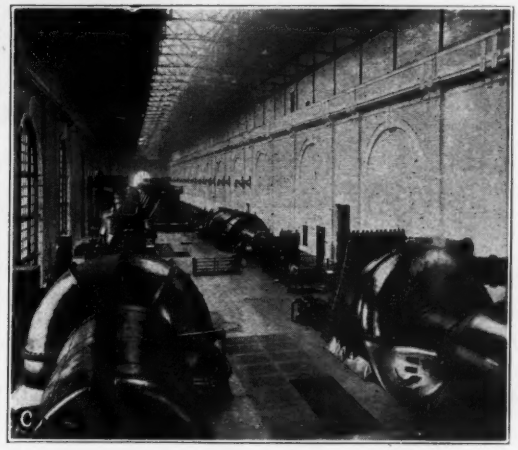
In summing up the reasons for the rapid development of the central station industry in this district, Mr. Insull cited proper methods of selling great amounts of energy to large wholesale users, proper distribution systems, use of large generating units and true engineering of central station construction and operation as probably the most important factors in bringing electric service to the homes and industries of northern Illinois. Credit was given to the late Frederick Sargent for the engineering vision and skill in practical accomplishment which made possible such rapid strides in central station development.





A. Dynamo room of Adams St. Generating Station of Chicago Edison Co., predecessor of the Commonwealth Edison Co. This station was placed in service in 1888 and operated until 1894. Maximum rating, about 3200 kw.; original generators, 80 kw. Picture taken about 1891. This was the first Edison central station in Chicago.

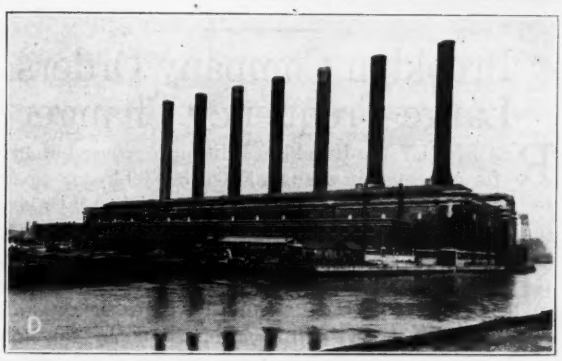
B. Engine and dynamo room of the Harrison St. Station of Chicago Edison Co. This station was placed in operation in 1894 and was in active service until 1910. In 1902, the maximum rating of 16,200 kw. was reached; largest unit 3500 kw.

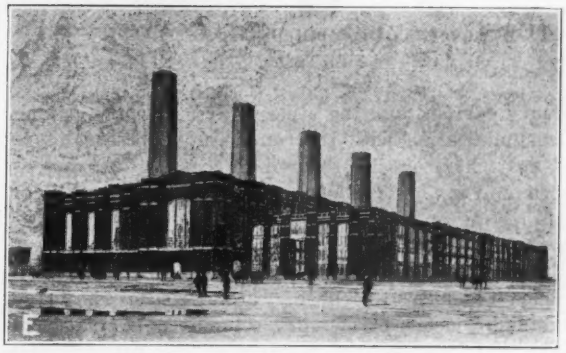


C. Just to show the improvement in station design, here is the Fisk St. station with its 230,000 kw. This was the first all turbine station in the world and has been altered and equipment added to bring it in line with modern practice. The units in the foreground are rated at 35,000 kw. each.

D. Fisk St. Station viewed from across the Chicago River. The first unit was placed in operation in 1903.

E. In the Crawford Ave. Station soon to be constructed, there will ultimately be 10 units, giving a station capacity of at least 400,000 kw. and possibly 600,000 kw.





SOME OF THE IMPORTANT STEPS IN CHICAGO CENTRAL STATION DEVELOPMENT WHICH WERE OUTLINED BY MR. INSULL

New Recorder for Determining Turbine Economy

IN THE operation of steam turbines, the existence of an unnecessarily high back pressure represents a considerable waste in steam consumption, and from this point of view the back pressure should always be kept at a minimum. In order accurately to determine the back pressure in steam turbine and condensing plants, there has recently been brought out by the Uehling Instrument Co., of Paterson, N. J., a new combined barometer and vacuum recorder.

This instrument is designed primarily for determining (1) the absolute back pressure, (2) the barometric pressure, (3) the condenser vacuum, (4) the existence of air leakage into the condenser, etc., and (5) the ability of the condenser to handle the load.

As shown in Fig. 1, the Uehling combined barometer and vacuum recorder consists merely of two-float chambers, one of which is connected with a barometric

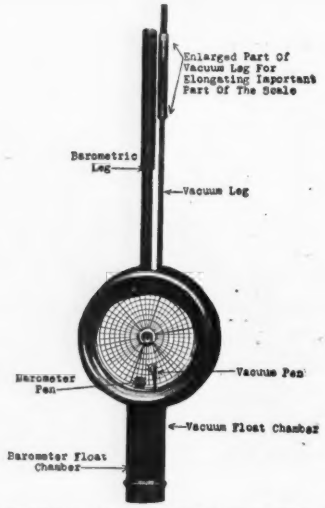


FIG. 1. NEW UEHLING COMBINED BAROMETER AND VACUUM RECORDER

mercury column, and the other with a mercury column in communication with the condenser. These columns and float chambers are secured to the recorder case as shown in Fig. 1. The pens are actuated by means of floats resting on the mercury in the two chambers. The movements of the floats correspond exactly to changes in barometric pressure and in vacuum.

Since the measurement of barometric pressure and vacuum by means of mercury columns is standard for power plant testing, the readings of the new recorder are at all times accurate and reliable. There is no necessity for calibrating the recorder against mercury column testers as is customary in other types of instruments.

This recorder draws automatically and continuously the barometer and vacuum records on the same chart, as may be noted in Fig. 2. The barometer record is used as a base line for reading the absolute back pressure directly off the chart. As long as the two curves, barometer and vacuum, vary simultaneously and proportionately, everything is as it should be. Should, however, the vacuum fall when the barometer remains constant, either considerable air is leaking into the condenser, or the condenser is not able to handle the load.

By means of the recorder chart, it is possible at all times to ascertain whether the turbine or condenser is operating as efficiently as it should, and to know whenever air is leaking into the system. The existence of

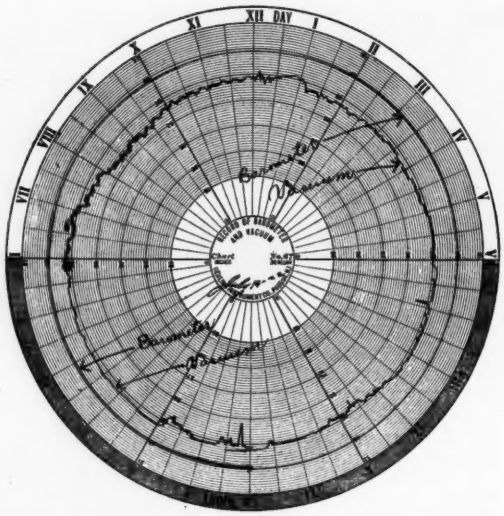


FIG. 2. TYPICAL CHART TAKEN ON NEW RECORDER

air leakage is instantly revealed, and thus can be located and eliminated by the engineer before an appreciable waste or heat loss is incurred. The instrument records any part of the total range of 0 to 31 in. Vacuums from 25 in. to 31 in., and the corresponding absolute back pressures, or vacuums from 20 in. to 31 in., etc., may be recorded with great accuracy over nearly the full face of the chart, the rest of the chart being used for recording on a contracted scale, the lower vacuums down to atmospheric pressure.

Brooklyn Company Orders Large Frequency Changer

RECENTLY the Brooklyn Edison Co. placed an order for a frequency changer set of 35,000 kv.-a. capacity for installation in its Gold St. station. The set is larger than any frequency changer set now in service in the United States and has over all dimensions, including the direct connected exciter, of approximately 47½ ft. in length, 22 ft. in width, and 15 ft. in height. It is expected that the set will be in operation by November, 1923.

This set, which will operate at 300 r.p.m., will connect the company's 25-cycle and 60-cycle systems, transforming energy from 13,800 v., three-phase, 60-cycle, to either 6600 v. or 11,400 v., three-phase, 25-cycle. The 60-cycle end of the set is connected directly to an auto transformer, through which the voltage is stepped up from 13,800 v. to 27,600 v. At this latter end, a tie line, running underground in three-phase lead-covered cables, will connect the set with the new power house which the Brooklyn Edison Co. is now erecting at Hudson Ave.

It will be possible to start from either end. For the 60-cycle end starting taps are to be provided on the auto transformer, and for the 25-cycle end it is proposed to connect the set directly to a generator in the station while the latter is at rest and to bring both the generator and the frequency changer set up to speed together. No starting motor will be provided. Excitation for both ends of the set is to be obtained from a common exciter of 300 kw. capacity. Hand regulation will be used for both ends of the changer. The set is to be built by the Westinghouse Electric & Manufacturing Co.

High efficiencies of the frequency changer set and of the new generating units for the Hudson Ave. station make it more economical to generate power at 60 cycles in the Hudson Ave. station, transmit it to Gold St. and convert it to 25 cycles through the frequency changer, than to generate the 25-cycle current directly, using some of the older machines now in operation in the Gold St. station.

Refractories Discussed by Metropolitan Section of A. S. M. E.

KENNETH SEAVER, chief engineer of the Harbison-Walker Refractories Co., spoke on the subject of refractories at a meeting of the Metropolitan Section of the A. S. M. E., held at the Engineering Societies' Building in New York on Jan. 23. The talk was illustrated with lantern slides showing the sources of raw material, process of manufacture and properties of the principal types of fire brick, with tests of the products and typical boiler furnace problems. Silicon brick, manufactured from ganister, and magnesia brick, employing magnesite with iron as an impurity, received particular attention.

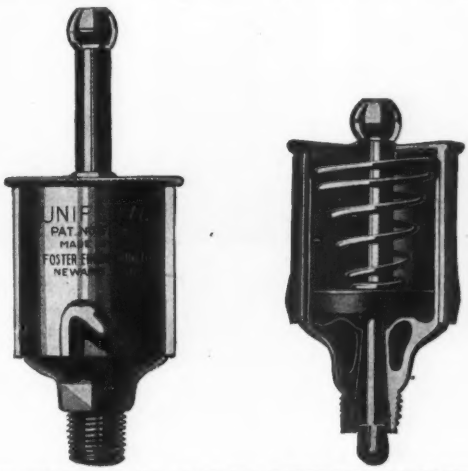
Discussion developed along lines of special interest to power plant men. E. B. Ricketts, of the New York Edison Co., pointed out that for boiler furnace work the more expensive special types of brick are generally not available on account of cost of manufacture and the necessity for using a local product to avoid excessive freight charges. He also referred to the importance of having uniform size, especially in respect to thickness. His remarks on this subject were strongly seconded by V. M. Frost, of the Public Service Electric Co., and W. C. Drake, of the Furnace Engineering Co. Mr. Ricketts emphasized the desirability of using a minimum of bonding material in order to prolong the life of the fire brick. The best construction, he said, would be the closest to all brick and no bond.

Solution of the sizing problem by careful selection during installation was proposed by A. W. Patterson, of the Engineer Co. He also recommended sifting of the fire clay to insure thinness and uniformity of joints. Extra protection from spalling and increased life of brickwork can also be had by leaving a bead of fire clay, which for ⅛-in. joint may be ⅛ in. above the face of bricks and be made to overlap them ¼ in. This arrangement postpones eating away of the bond between bricks and consequent exposure to disintegration from two sides. At the invitation of J. H. Lawrence, who presided over the discussion, Mr. Patterson told of some instances of improvement in the life of brickwork through changes in bridgewalls and baffling of boilers, whereby the cross-sectional area of the first pass had been increased with consequent reduction of velocity of the hotter gases and increase in velocity of the comparatively cool gases.

Replying to questions from the floor, Mr. Seaver explained that the manufacture of brick of uniform size was impossible owing to the wide variation of conditions in the kiln, especially with respect to loading and stresses in the brick in different sections of the kiln. On the question of what tolerance should be allowed, he said that this depended largely upon the price paid; that selection to size could be made before delivery, and in case of thickness, brick to have a variation of not over ¼ in. in 10 in. height should be readily obtained.

Lubricator Feeds Uniformly Regardless of Spring Pressure

SINCE the spring pressure in a grease lubricator of the automatic feed type varies depending on whether the cup is full or nearly empty, the feed of grease is not uniform unless some method is used to control the size of the feed opening. In a lubricator



FEED NOZZLE OPENS AS SPRING PRESSURE DECREASES IN THIS LUBRICATOR

which has recently been placed on the market, the uniformity of feed is obtained through the use of a tapered feeding nozzle and a tapered plug.

When the cup is full the spring is compressed all the way and the pressure it exerts on the grease is greatest, so the plug in the outlet is pulled up to the top of the outlet taper. As the grease is displaced the spring expands, the spring pressure is weakened and the plug moves down in the tapered outlet and the outlet is enlarged. The lessening pressure is therefore compensated for by the widened opening and the feed of grease is maintained uniform. In the sectional view shown in the accompanying illustration, the spring is expanded to its greatest distance and the nozzle is in full open position.

To fill these lubricators, the cap may be removed by giving it a slight twist to the left and the grease container is then exposed. When the cup is filled the indicating ball is at its highest point.

This type of lubricator is marketed by the Foster Engineering Co., of Newark, N. J., under the trade name of Foster Uniflow Lubricators.

New Boiler Coating Material Gives Good Results

DUE TO the high furnace temperatures that are now commonly employed in the boiler room, furnace maintenance may be excessive owing to the inability of some of the fire brick used in the furnace linings to withstand these temperatures. A coating designed to withstand these high temperatures, Maphite, has recently been put on the market by the Boiler-Kote Co., of Chicago. Great refractory quantities, less clinker adherence, low cost and low maintenance and air and gas tightness are qualities claimed for this material.

Maphite is a mineral compounded into a paint.. This paint is mixed with a dry powder to produce a paste, and this paste is used to fill in spalled out places and cracks in the lining. Where extreme temperatures are encountered a thin coat of the paste may be troweled

FIG. 1. VIEW OF COMBUSTION ARCH AFTER IT HAD BEEN IN SERVICE FOR ABOUT A YEAR

FIG. 2. APPEARANCE OF THE COMBUSTION CHAMBER AFTER THE COATING HAD BEEN APPLIED

FIG. 3. AFTER FIVE MONTHS' OPERATION THE LINING WAS INTACT AND IN GOOD CONDITION

over the entire firebox. In furnaces not subjected to severe temperatures it is sufficient simply to fill the spalled places and cracks with paste and then go over the rest of the lining with two coats of the paint.

Illustrations shown are those of the combustion arch in a 350-hp. Stirling boiler which develops anywhere from 350 to 750 hp. The first illustration shows the arch after about one year of service. Considerable checking and spalling had developed. In repairing this lining the paste was first used to fill in the holes and then a thin coat was troweled over the entire surface. This work was done while the setting was still as warm as could be worked on comfortably. After the paste had been allowed to set over night two coats of paint were applied.

The result is shown in Fig. 2. After 5 mo. of continuous service under conditions comparable to those of the first year, the condition of the lining was as shown in Fig. 3. During this time, the attention given the fire box consisted of some small patch work and an occasional coat of paint.

This material shows no tendency to run at extreme temperatures, nor does it soften at even 2200 deg. F., but maintains a hard glazed surface to which clinker has but little tendency to adhere.

News Notes

IN ACCORDANCE with the request of the engineering societies the American Engineering Standards Committee, whose machinery during the last four years has been the accepted medium for national standardization of raw materials, industrial processes and manufactured products in the engineering field, will call a conference to consider the standardization of abbreviations and of the symbols used in engineering equations and formulas.

EXCESSIVE COST of coal in the metropolitan district has led the Mount Sinai Hospital to begin changing from coal burning to oil burning equipment; and a number of other hospitals belonging to the United Hospital Fund have called for bids, with a view to similar action. Among these are Saint Luke's, the Manhattan Eye and Ear Hospital and the New York Hospital. It is said that the average coal consumption of the 58 hospitals connected with this organization amounts to about 5000 T., costing in the neighborhood of $50,000 a year for each institution.

TAKING EXCEPTION to the stand of the American Federation of Labor in opposition to the Ship Subsidy Bill, Thomas B. Healy, manager of the New York local of the National Association of Marine Engineers, announced on Jan. 23 the separation of this organization, which numbers 22,000 members, from the Federation. He stated that present conditions in the America shipping industry are responsible for thousands of these marine engineers being unemployed, and that the attitude of the Federation is based on the opposition of the International Seamen's Union, which is composed largely of foreigners who would be adversely affected by the bill.

A. R. GIBBONS, of Johns-Manville, Inc., gave a talk on the subject of Asbestos at the Brooklyn Engineers' Club on Jan. 23. The talk, which was illustrated by four reels of motion pictures taken by the Bureau of Mines at the mining and manufacturing properties of the company, gave a comprehensive idea of the operations involved in getting out the rock and converting it to many uses. Mr. Gibbons stated that the largest asbestos deposits in America are found in the Province of Quebec, where the town of Asbestos, with a population of 5000, is supported entirely by this industry. Here the ore is blasted out and crushed and the fiber separated by milling processes. This fiber runs much shorter than that found at the remote mine at Chrysotil, Ariz., where the fiber reaches a length of several inches. At Chrysotil the asbestos is dug out by hand, the miners following the veins as in coal mining. The longer fiber is, of course, particularly useful for weaving into fabric. As the Arizona mine is 65 mi. from the nearest railroad, and transportation for a fourth of the distance is by burros over mountain trails, the difficulty of getting out the rock from there is considerable.

NOTABLE ENGINEERING achievements of Benjamin G. Lamme, chief engineer of the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., were officially recognized by his alma mater, Ohio State University, Friday, Jan. 12, when the university presented to Mr. Lamme the Joseph Sullivant medal. The presentation was made in the presence of the trustees and faculties of the Ohio State University at appropriate ceremonies

in the chapel of the university, Dr. W. O. Thompson, president, making the presentation address and formally presenting the medal to Ohio State's son, now one of the very foremost of the nation's electrical engineers. Mr. Lamme, in accepting the medal, delivered a brief address in which he modestly avoided reference to his own achievements, but strongly emphasized the importance of the engineering profession and the electrical industry, and pointed out the opportunities for college men in the field work.

BETHLEHEM SHIPBUILDING CORPORATION announces the appointment of H. G. Smith as vice president in charge of sales, with offices at 25 Broadway, New York.

DETROIT STOKER CO. announces the removal of its works to Monroe, Mich. The general offices, engineering and service departments will be continued in their present location in the General Motors Building, Detroit.

GEO. T. LADD CO., of Pittsburgh, Pa., manufacturer of water tube boilers, has announced the appointment of C. M. Decker as sales representative in the Philadelphia territory, with offices at 2128 Land Title Bldg.

ROYAL E. TERHUNE has been placed in charge of the Northern New Jersey sales territory of the Uehling Instrument Co., Paterson, N. J., manufacturer of CO_2 recorders and other power plant equipment. Mr. Terhune was formerly associated with the Uehling Laboratories.

MINE AND SMELTER SUPPLY CO., with branches in Denver, Salt Lake City and El Paso, has taken over Wilson Welder & Metals Co.'s exclusive representation for the states of Colorado, Utah, Nevada, Wyoming, New Mexico and Western Texas for Wilson plastic-arc welders and Wilson welding metals.

STANDARD CONVEYOR CO. has acquired by purchase all the rights to the "Brown Portable" line of elevating, conveying, loading and unloading machinery for the handling of packed and loose materials. This line of machinery has been manufactured by the Brown Portable Conveying Machinery Co. at North Chicago for 10 yr.

GEORGE E. LEARNARD, president of the International Combustion Engineering Corporation, sailed on the Olympic Saturday, Jan. 20, for London, to inspect the company's new plant at Derby, later visiting the works at Rubeaux and the company's new offices in Paris, which, because of increased demands, have recently been more than doubled in size.

CHARLES H. TENNEY CO., of Boston, which operates several gas and electric companies, has taken over control of the Beverly Gas & Electric Co., of Beverly, Mass. Andrew W. Rogers, president of the Beverly company, will remain in that capacity for the present at the request of the Tenney interests and will have charge of the active management of the concern.

AMERICAN ENGINEERING CO., of Philadelphia, manufacturer of Taylor stokers and marine auxiliaries, has taken over the Standard Crane and Hoist Co. and the patent and manufacturing rights to the mono-rail electric hoist, formerly known as the Standard.

H. S. Valentine, chief engineer of the Standard Crane and Hoist Co., is directing the sales and supervising the manufacture of the hoists. The American Engineering Co. has reorganized its No. 1 plant to accommodate the work of building and testing the hoists on a commercial basis and is now manufacturing them in quantity.

DIRECTORS OF Gifford-Wood Co. at a recent meeting appointed Joseph A. Boucher to the position of sales manager, to become effective at once. Mr. Boucher spent his first few years in the company's offices at Hudson, N. Y., much of his time being devoted to engineering work, eventually joining the sales force and later being assigned to the New York office. Upon taking up his new duties, Mr. Boucher will be located at the company's main office at Hudson, N. Y.

JOHNS-PRATT CO., of Hartford, Conn., which is now marketing Vulcabeston sheet valve stem and rod packings through regular trade channels, announces the following territorial representatives: Fleck Brothers, Ltd., Vancouver, B. C.; Globe Machinery & Supply Co., Des Moines, Ia.; Manning Packing Co., Portland, Ore.; Hartford Mill Supply Co., Hartford, Conn.; Hanks-Price Co., Minneapolis, Minn.; F. K. Carlon & Co., Norfolk, Va.; Electric Hose & Rubber Co., Ltd., London, England; Vulcan Copper & Supply Co., Cincinnati, Ohio.

ZUCE KOGAN, consulting combustion engineer, has opened an office at 1119 S. Kedzie Ave., Chicago, Ill. Mr. Kogan has made a specialty of designing boiler furnaces for burning fuels containing high percentages of moisture and volatile matter such as sawdust, bagasse and refuse.

ANNOUNCEMENT is made by the Conveyors Corporation of America, 326 West Madison St., Chicago, of its acquisition from the Green Engineering Co., of all rights to the Green steam jet ash conveyor. The transaction, which became effective Feb. 1, 1923, gives to the Conveyors Corporation of America all the patterns, patents and manufacturing rights pertaining to the Green conveyor. All orders for replacement parts and extensions to the Green conveyor will be filled by the Conveyors Corporation of America.

WORK IS WELL under way on the new $700,000 building being constructed for the Westinghouse Electric & Manufacturing Co., at Chicago. The building, which is located at West Pershing Road and Leavitt St., will be used for a combination district sales office, warehouse and service shop, and is the first of three buildings to be erected at this location. It will be seven stories high, will contain 218,000 sq. ft. of floor space, and will be of reinforced concrete construction. Work was started Nov. 1 and will be completed about the first of next May.

CUMBERLAND COUNTY POWER & LIGHT CO., with offices in Portland, Me., has filed a petition with the Public Utilities Commission of the state seeking the right to acquire by purchase the properties of the York County Power Co. and the Westbrook (Me.) Electric Co. For the past 10 or 12 yr. both of these companies have been operated by the Cumberland County Co., which already owns the common stock of both companies and now seeks to acquire the other outstanding stock.

FOUNDATION work has been completed for the power development project at Lake Sunapee, N. H., of the Lake Sunapee Power Co. The water wheel to be used has been ordered from the Worthington Pump Co. and the generators from the Electric Machinery Manufacturing Co. The plant will cost approximately $300,000.

EXCAVATION WORK has been started by the Connecticut Light & Power Co., of Danbury, Conn., for its power plant on the Housatonic River in Devon, Conn., where, on a 55-acre tract, it is to build one of the largest power plants in the Connecticut valley. It is estimated that the plant and equipment will cost in the vicinity of $4,000,000. The company proposes to produce electricity for power and lighting for several nearby places and will construct about 75 mi. of high tension wires. Service will be supplied to towns in the Naugatuck Valley, besides supplementing the service already furnished New Britain and Bristol, Conn.

GREAT NORTHERN PAPER CO. is erecting a hydroelectric power plant at Madison, Me., at the Madison and Anson bridge, capable of developing 4000 hp. The company bought the old pumping station of the Madison water district, but the main part of the plant will be located on the Anson side of the bridge. Preliminary work will be carried on this winter so that actual construction and cement work may start early in the spring.

U. S. CIVIL SERVICE COMMISSION announces an examination for mechanical engineer (precision instruments) to fill a vacancy in the Coast and Geodetic Survey, Washington, D. C., at $3000 a year, and vacancies in positions requiring similar qualifications, at this or higher or lower salaries. Receipt of applications will close Feb. 20. As the Commission has had difficulty in securing eligibles for this position, qualified persons are urged to apply. Applicants must show that they have been graduated in engineering, preferably mechanical engineering, from a college or university of recognized standing; and that, in addition, they have had at least 3 yr. experience as a successful designer of precision instruments, preferably instruments used in surveying; applicants who have successfully completed at least 2 yr. of such engineering course may substitute, for each year lacking completion of such course, an additional year of experience of such a nature as to qualify them to design precision instruments. Applicants must have reached their twenty-fifth but not their forty-fifth birthday on the date of the examination. Apply for Form 1312, stating examination title.

Catalog Notes

A MESSAGE ON combustion issued by the Engineer Co., of New York, N. Y., consists of a discussion of how the Turner Baffle Wall is used and some of the results which have been obtained through changes in baffle wall arrangement.

NATIONAL TUBE CO., Pittsburgh, Pa., discusses details of "Shelby" steamless hot rolled boiler tubes in issue No. 12 of its National Bulletin. The process of making hot rolled boiler tubes is described and points are presented as to the physical properties, advantages and disadvantages of the hot rolled process as compared with tubes made by cold rolling.

CATALOG C-1 of the Elliott Co., Jeannette, Pa., gives a complete description of Elliott Ehrhart condensers of the jet, barometric and surface types, and there is also a section on air ejectors and single-stage and two-stage ejectors with both inter- and after-condensers. The test of condensers is gone into and curves are shown which present the results of tests. A section on special condenser applications gives engineering data relative to various types of condenser installations, including information on condenser foundation designs.

A CLOSE-UP of stoker manufacture is presented in a folder on this subject by the Sanford Riley Stoker Co., Worcester, Mass. It gives an idea of the equipment available for building Riley underfeed, Jones' underfeed and Murphy automatic stokers.

CATALOG No. 26, describing Jones spur speed reducers, is now being distributed by the W. A. Jones Foundry & Machine Co., of Chicago. Technical and practical information on speed reduction problems is presented, together with numerous illustrations of drives used in large industrial plants.

STEAM SPECIALTIES and a description of the Kieley high pressure automatic boiler water feeder are presented in bulletins which have recently been issued by Kieley & Mueller, Inc., of New York. Sectional views of reducing valves, back pressure valves, steam traps and other apparatus made by this company are shown.

HARRINGTON STOKERS are discussed in a 32-page bulletin published by the United Machine & Mfg. Co., of Canton, Ohio. Principles of design of this forced draft type of chain grate stoker are taken up, adaptability of various fuels discussed and typical applications illustrated.

BOILER FURNACE ECONOMY is discussed in Bulletin No. 53 by the Quigley Furnace Specialties Co., of New York, N. Y. Methods are shown which give an idea of how boiler furnace walls may be re-constructed through the use of crushed fire brick or other ganister bonded with Hytempite which is made by this company.

CHANDLER & TAYLOR steam engines for direct connection to electrical generators are illustrated and described in Bulletin No. 135, now being distributed by the Chandler & Taylor Co., of Indianapolis. Details of construction are shown for both the simple and compound type in ratings for the former of from 25 to 300 kw. and for the latter from 50 to 500 kw.

NATIONAL VALVE AND MANUFACTURING CO. is distributing catalog No. 5, entitled "Dimensions for Piping Equipment." This catalog gives dimensions for the recognized classification of valves, fittings and flanges in regard to pressures and temperatures. It also illustrates valve operating mechanisms and contains a reprint of the "Standard Specifications for Power Piping," as revised Jan. 27, 1922, by the Power Piping Society. Several charts and tables are also given, which will prove convenient in solving piping problems.

BULLETINS have been published by the Bureau of Mines as follows: Bulletin 167, relating to coal-dust explosion tests in the experimental mine, 1913 to 1918, inclusive, by G. S. Rice, L. M. Jones, W. L. Egy, and H. P. Greenwald, discussing results of 480 explosion tests, including dusts of different coals, with and without gas Bulletin 193, on analyses of mine and car samples of coal collected in the fiscal years 1916 to 1919, by A. C. Fieldner, W. A. Selvig, and J. W. Paul, giving analyses of 1600 samples of coal from many coal fields in the United States, and notes on the mines sampled.